

**Crop Production Technology-II (oil seeds, fibre, sugar,
tobacco and fodder crops) (Rabi crops)**

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MS SWAMINATHAN SCHOOL OF AGRICULTURE

B.Sc.Ag(Hons).

Crop Production Technology-II (oil seeds, fibre, sugar, tobacco and fodder crops)(Rabi crops)

Course no. – ASAG2204

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Lecture -1

1.1 Wheat

Scientific name: *Triticum aestivum*

Family: Gramineae or Poaceae

1.2 Origin:

The origin is south-west Asian countries from where it reached to European countries. There are 18 species of wheat. The important cultivated wheat species in India are hexaploid [AABBDD], *Triticum aestivum* Common bread wheat (n=21), Tetraploid [AABB], *Triticum durum* Macaroni wheat (n=14), Diploid [AA] and *Triticum monococcum* Emmer wheat (n=14).

In India only three species of wheat namely *Triticum aestivum* (common bread wheat), *Triticum durum* (macaroni or durum wheat), *Triticum dicoccum* (emmer wheat) are economically important. The bread wheat (*Triticum aestivum*) is the most important species accounting to a little over 87 per cent of the total wheat production of India followed by the durum wheat (about 12 per cent) and dicoccum wheat (about 1 per cent). The common wheat (*T. aestivum*) which is good for chapati making and bakery products is grown in whole of North India and also in Central and South India. The durum wheat which is good for 'suji', 'semya', 'sphagetti' and 'macaronil' is grown only in Central and South India and that too under rainfed conditions. The dicoccum wheat is grown only on limited acreage in Tamil Nadu, Andhra Pradesh, Maharashtra and Gujarat. It is good for the South India dish 'Uppumav'.

1.3 Classification of Wheat

Einkorn series (diploid)

Chromosome No.

1. *Triticum aegiloploids*=7
2. *Triticum monococcum*=7

Einkorn Series (tetraploid) *Triticum dicoccoides*=14

1. *Triticum timopheevi*=14
2. *Triticum persicum*=14
3. *Triticum polonicum*=14
4. *Triticum turgidum*=14
5. *Triticum orientale*=14
6. *Triticum durum*=14
7. *Triticum dicoccum*=14

Dinkale series (hexaploid)

1. *Triticum spelts*=21
2. *Triticum macha*=21
3. *Triticum aestivum* or *vulgare*=21

- *T. aestivum*, the bread wheat is grown under 85 % of total area cultivated under wheat in India.

- *T. durum*, the macaroni wheat, is the 2nd most important sps. Of wheat occupying about 14% of wheat area in India. Its cultivation is confined to central and southern India only.
- *T. monococcum* or emmer wheat is grown on a very restricted scale in Saurashtra region of Gujarat, southern Maharashtra, Karnataka, some parts of Andhra Pradesh and Tamil Nadu.

1.4 Botanical Description of wheat

Wheat plant can be divided in 2 distinct parts, viz., root system and shoot system.



1.4.1 Root system

There are 2 sets of roots in wheat. The seminal or seedling roots belonging to embryo, and are produced by the germinating seedlings. It arises at the depth where the seed is planted. As plant growth progresses, this primary root system usually dies, and is replaced by the more permanent secondary root system. The second set of roots is called as 8-9 clonal roots, which arises from the basal nodes of the plants and form the compact vegetative mass known as 'crown'. The entire roots are adventitious. The second set forms the permanent root system, while the seminal roots dry after about 30 days of the seedlings emergence.

1.4.2 Shoot system

This system collectively applied to all the visible parts above the ground. It comprises of stems, leaves and inflorescence. A stem and inflorescence may be called a 'culm'.

Stem: The stem of wheat plant is erect, cylindrical, jointed and smooth. In bread wheat, the stems are hollow, except at the nodes where they are solid, but in a few cultivars of Macaroni wheat, the internodes are completely filled with soft pith. **Leaves:** The wheat leaves consists of the following 4 parts. **Leaf sheath:** The basal part of the leaf, which encircles the stem and the blade that bends away from the stem. **Leaf blade:** the flattened, parallel veined portion of the leaf. **Ligule:** the membranous outgrowth is called ligule. **Auricle:** lobes of the leaf blade, which extend downward on each side at the junction of the blade and sheath. These are claw-like appendages projecting from the collar of the leaf.

1.4.3 Inflorescence

The inflorescence is known as 'ear' or 'head', but its botanical name is spike. Spikelets are systematically arranged and are distributed along the central zig-zag axis rachis. The spikelets are borne on alternate sides of the rachis, which gives it a zig-zag appearance. Spikelet: It is composed of flowers called florets. The number of florets in a spikelet may vary from 1 to 5. The florets in each spikelet are enclosed by 2 glumes. Kernel: Wheat has a 'caryopsis' type of fruit. The typical wheat kernel is 3 to 10 mm in length and 3 to 5 mm in diameter.

Lecture-2

2.1 Growth Stages

Various Growth Stages of Wheat Plant Wheat plant passes through various stages of growth, as described below:

2.1.1 Growth stages in wheat in North India

2.1.1.1 Vegetative

- Germination : 5-7 days
- CRI : 20-25 DAS
- Tillering: from 15 days at 4-5 days until 45 DAS
- Jointing: Peak plant growth 45-60 DAS
- Internode elongation period: 60-70 DAS

2.1.1.2 Reproductive

- Boot leaf 70-75 DAS
- Flowering : 85-90 DAS
- Milking: 100-105DAS
- Dough: 105-110
- Maturity: 115 – 120.

2.2 Important stages of crop growth

2.2.1 CRI: In wheat, the first node of crown is formed near the soil surface irrespective of the depth of sowing. Crown roots start developing at this node. Depending upon temperature, CRI takes place 15-21 DAS. Plants at this stage are very sensitive to soil moisture stress. Hence, there is a need for adequate moisture at this stage.

2.2.2 Tillering: The lateral buds at these nodes give rise to tillers. Tiller initiation takes place 4 weeks after sowing and tillers continue to emerge for another 2 or 3 weeks.

2.2.3 Jointing stage: It represents the node production and active growth period. Up to this stage, the seedlings consists of a whorl of leaves. At this jointing stage, the stem becomes visible with distinct nodes.

2.2.4 Heading: This is the stage where the internodes begin to elongate. Flag leaf and ear emerge towards the end of this stage. Adequate moisture should also be present in the soil at the heading stage.

2.2.5 Grain development: It is up to the end of soft dough stage of the grain. At this stage also, the plant requires adequate moisture at dough stage.

2.3 The area: 302.27 lakh ha, Production: 93.5 million tonnes, Productivity: 3093 kg/ha (in India). India ranks 2nd in wheat production in the world.

| Countries | A (000ha) | P (000t) | Y (kg/ha) | % |
|-----------|-----------|----------|-----------|--------|
| World | 220000 | 729000 | 3314 | 100.00 |
| China | 24100 | 157000 | 6515 | 21.54 |
| India | 30500 | 95900 | 3144 | 13.16 |

2.4 Zones of India for growing wheat

- North West Plains Zone
- North East Plains Zone
- North West Hills Zone
- Central Zone
- Southern Hill Zone
- Peninsular zone

2.5 Varietal improvement in India

Earlier (Imperial now) Indian Agricultural Research Institute (IARI), Pusa developed some varieties like Sarbati, Dara, Hard Red Calcutta, Bansi and Malvi of *T. aestivum* and Kandwa of *T. durum* wheat. In India, a major breakthrough in wheat production started in 1967-68 with the introduction of Mexican Dwarf Wheat Ideotype. Mexican dwarf wheat ideotype is having Norin10 gene. Norin10 gene was brought by Important characteristics: Dwarf in height, erect leaf, responsive to fertilizer N and irrigation, synchronous tillering and maturity, preventive to lodging, less susceptible to diseases. Introduction of dwarf wheat provided a spurt in wheat production in India in 1963 with the introduction of Mexican Dwarf Varieties namely, Sonara 64 and Lerma Rojo.

2.5.1 Recommended varieties for north-west plains zone (NWPZ)

Timely sown irrigated crop : HD 2687, HD 2428, HD 2204, CPAN 3004, Raj 307, PBW 154, WH 542, UP 2338, Raj 3765, PBW 343, DBW 17, PBW 550, PBW 502, WH 542, PDW 291(d), PDW 233(d), WH 896 (d)

Late sown irrigated crop: HD 2285, HD 2688, HD 2270, PBW 226, Raj 3077, UP 2338, PBW 435, UP 2425, PBW 590, WH 1021, DBW 16, PBW 373, Raj 3765

Rainfed: C 606, IWP 72, Kundan, WL 410, PBW 175, PBW 396

2.5.2 Recommended varieties for north-east plains zone (NEPZ)

Timely sown irrigated crop: Janak, PU 262, HP 1102, UP 2003, HUW 206, HD 2407, K 7410, K 9107, Vaishali, HD 2824, HD 2733, PBW 443, PBW 343, HUW 468

Late sown irrigated crop: HD 2307, HD 2285, HD 2643, HP 1209, K 8020, K 8962, HW 1014, HW 2045

Rainfed: C 306, K 8027, K 8962, K 9465, HD 2888

2.5.3 Recommended varieties for north-west hills zone (NWHZ)

Timely sown irrigated crop: CPN 1796, HB 208, HD 2380, SS 240, UP 1109, BW 738, BL 804, BL 738, HS 240 For high altitude: HS 365, BL 832

Late sown irrigated crop: WL 421, CPAN 1796, HB 208, HD 2380, HS 240, UP 1109, HS 420, HPW 42

Rainfed: SS 277, SS 207, HS 295, HS 240, VL 804, VL 738

2.5.4 Recommended varieties for central zone

Timely sown irrigated crop: Kanchan, Raj 1555, HI 1544, HI 8381, Lok 1, GW 1139, GW 273, HD 2236

Late sown irrigated crop: GW 173, Sonalika, Vidisha Lok 1, Swati, HD 2327, HD 2932

Rainfed: Narmada 4, Mukta, C 306, Meghdoot, Sujata

2.5.5 Recommended varieties for sz

Timely sown irrigated crop: DWR 162, SD 4502, Kirti, HD 1085, HD 2380

Late sown irrigated crop: Sonalika, HD 2501, DWR 195

Rainfed: MACA 1367, NI 5439, N 59, Vijinga Yellow

2.5.6 Recommended varieties for Peninsular Zone

Timely sown irrigated crop: GW 322, DWR 162, HD 2189

Late sown irrigated crop: PBW 533, HD 2932, HD 2833, Raj 4083

Rainfed: PBW 596, HD 2781, K 9644, NI 5439

Lecture -3

3.1 Categories of Indian Bread Wheat (consumed as ROTI/ CHAPATI)

3.1.1 Indian Amber Wheat: Bold grain, amber, translucent, lustrous, 11% protein, popular among elite customers. Varieties: C 306, Sujata, HD 2781, HD 2189, HD 2833, UP 262, HW 2045, Lok 1, Raj 3077

3.1.2 Indian Sona Wheat: Medium grain, medium hard, cultivated in large area in India (NWPZ and CZ), 10% protein. Varieties: HD 2285, HD 2733, HD 2643, HD 2687, PBW 343, PBW 373, UP 2338, UP 3425, WH 542, WH 147, HP 1731, HUW 234, GW 193, GW 190

3.1.3 Indian Pissi Wheat: Grains are medium sized, less than 10% protein, produced in NEPZ, CZ and NHZ. Used to make biscuits, cake. Varieties: Sonalika, Pissi local, HB 208.

3.1.4 Indian Hard Wheat: Medium bold grains, translucent, hard with 12% protein. Cultivated in Karnataka, Gujarat, Maharashtra and parts of MP and used in Bakery bread. Varieties: HI 977, K 9107, Raj 1482, GW 496, DWR 162, DWR 195.

3.1.5 Durum wheat: Central and PZ, used for making of pasta, vermicelli, macaroni, spaghetti.

Varieties: HI 8498, HI 8381, PDW 233, WH 896, MPO 1066 .In India, wheat is grown in areas with annual rainfall varying from 300 -1130mm. It can also be grown in high attitudes. It is grown in Kashmir at an altitude of 2000-3000 m MSL.

3.2 Soils

In India, wheat is grown in different soils; but it does well on well drained loams and clay loams. Best growth is achieved in alluvial soils of Gangetic plains; but it does also well on black cotton soils of central India, Gangetic alluvium of U.P and Bihar, Indus alluvium of Punjab and Harayana, Black soils of central and southern India, Hilly soils of Himalaya and Desert soils of Rajasthan

3.3 Climate

Wheat is grown in all types of climatic conditions i.e. tropical, sub-tropical and temperate. In India, major Wheat area is under sub-tropical region. The cool and sunny winters are very conducive for growth of Wheat crop. The following temperature is required for optimum growth and development.

| Growth stages | Temperature requirements |
|----------------------|--------------------------|
| Germination | 20 to 25°C mean daily |
| Accelerated growth | 20 to 23°C mean daily |
| Proper grain filling | 23 to 25°C mean daily |

3.3 Season

In India, wheat is grown during rabi or winter season. The high temperatures on both ends of wheat season restrict the cultivation of this crop in India. Hot summer during the grain ripening period hastens the maturity of the crop giving inferior quality of the crop.

3.5 Sowing and seed rate

| Seeding time | Seedrate (kg/ha) | Time of sowing | Spacing (cm) | Seeding depth |
|-----------------------|------------------|----------------|--------------|---------------|
| Irrigated timely sown | 100 | 10-25 Nov | 20-22.5 | 5-6 cm |
| Late sown irrigated | 125 | 25 Nov -25 Dec | 15-18 | 5-6 cm |
| Rainfed timely sown | 100 | 15 Oct-30 Nov | 20-25 | 6-7cm |

3.6 Time of sowing

| Zone | Optimum sowing time |
|----------------------|---|
| North western plains | 1 st fortnight of November – short duration varieties 2 nd fortnight of November – long duration varieties |
| North eastern plains | 2 nd week of November – short duration varieties 1 st week of November – long duration varieties |
| Peninsular zone | October 2 nd fortnight for all varieties |

In India, wheat is grown in areas with annual rainfall varying from 300 -1130mm. It can also be grown in high attitudes. It is grown in Kashmir at an altitude of 2000-3000 m MSL.

3.7 Methods of sowing : There are 5 methods for sowing wheat namely

1. Broadcasting– cheap and quick method
2. Sowing behind the plough with hand- irrigated areas (PORA)
3. Sowing behind the plough with seed drill (KERA)
4. Dibbling- Dibbling 2 or 3 seeds by hand at 4-6 cm depth at a distance of 22.5 cm between rows and 10 cm between plants in a row. It is a good method for quick multiplication of pure seed material on a small scale. But it is laborious and time consuming for large scale sowing.
5. Zero / No-tillage sowing
6. FIRB – Furrow irrigated raised bed system

3.8 Advantages of zero tillage wheat

- Timely sowing
- Better placement of seed and fertilizers
- Less seed requirement
- Less requirement of labourer
- Line sown and optimum plant stand
- Easy inter-culture & management
- Less cost involvement in sowing & ultimately less CoC; more profit.

3.9 Preparatory cultivation

It requires well pulverised but compact seed bed for good and uniform germination.

Traditional land preparation includes 1 deep ploughing followed by 2-3 harrowings, 3-4 ploughings in summer, repeated harrowing in the rainy season followed by 3 or 4 cultivator workings and plannings immediately before sowing produce a good fine seed bed for the dry crop on alluvial soils. Timely cultivation and conservation of moisture are essential. In black cotton soils blade harrow is used instead of the plough

3.10 Spacing

- Rainfed: 30 cm row to row
- Irrigated areas: 22.5 cm row to row
- Favourable conditions : 30 X 10-15 cm (dibbling)

3.11 Depth of sowing The depth for dwarf varieties: 5-6 cm and tall varieties : 8-9 cm

Lecture -4

4.1 Fertilizers

Apply 10 tonnes of FYM /ha before 5-6 weeks of sowing .Entire P & K and ½ of N to be applied 5 cm below the seed at the time of sowing. Remaining ½ N should be applied at the time of 1st irrigation i.e. at the CRI stage (i.e. 21 DAS). In medium to heavy soils application of nitrogen in two splits i.e. half at the time of sowing and half after first irrigation. In case of light soils, nitrogen applied into three splits i.e. one-third at sowing time, one-third after first irrigation and remaining one-third after second irrigation. In case of Zn deficiency, 25-50 kg ZnSO₄/ha is to be applied as a basal dose in the soil.

| | Nitrogen (Kg/ha) | Phosphorous (Kg/ha) | Potassium (Kg/ha) |
|------------------------------|------------------|---------------------|-------------------|
| Timely sown irrigated | 120-150 | 40-60 | 40 |
| Late sown irrigated | 80-100 | 40-60 | 20 |
| Rainfed wheat | 60 | 20 | 0 |

4.2 Weed management

First 25-40 DAS is critical for weed competition. Grassy weeds: *Phalaris minor*, *Avena fatua*, *Cynodon dactylon*, *Poa annua*, *Polypogon monospliensis* Sedges: *Cyperus rotundus*, *C. esculentus* Broad leaves: *Chenopodium album*, *Rumex retroflux*, *Convolvulus arvensis*, *Argemone mexicana*, *Melilotus indica*, *M. alba*.

4.3 Management

- Hand weeding with Khurpi or hand-hoe at 20-25 DAS.
- Pre-emergence application of Pendimethalin @ 1kg a.i./ha in 500-750 l/ha of water with in 3DAS to provide broad spectrum weeds control.
- Post-emergence application of Cladinifop @ 60 g a.i./ha OR Sulfosulfuron @ 25 g a.i./ha in 200-250 l/ha of water within 25-30 DAS to control *Phalaris minor* and other grassy weeds.
- For broad leaved weeds application of Metribuzin @ 200 g a.i./ha in 500 l/ha of water during 25-30 DAS is effective.

4.4 Insect, pest and disease management

| | |
|--|---|
| Rust Brown, rust yellow rust black rust | <ul style="list-style-type: none"> • Mixed cropping with suitable crops. • Avoid excess dose of nitrogenous fertilizers. • Spray Zineb at 2.5 kg/ha or Propioconazole @ 0.1 %. • Grow resistant varieties like PBW 343, |
|--|---|

| | |
|-----------------------------|--|
| | PBW 550, PBW 17 |
| Powdery mildew | Spray <u>Wettable sulphur</u> 0.2% or Carbendazim @ 500 g/ha |
| Loose smut and Karnal burnt | Vitavax 2.5 g/kg seed |
| Army worms | Carbaryl 50 WP in 1000 litre of water (15 day interval) |
| Rat | Aluminium phosphide |

4.5 Irrigation

A life saving irrigation is necessary for uniform germination and good plant stand. Total water requirement is 300-400 mm. In light soils (which tend to form hard crust), irrigate and then sow the seed. In heavy soils it is better to sow in dry soil and then irrigate.

- i) CRI (21 -25 DAS)
- ii) Jointing (45 DAS)
- iii) Heading (65 DAS)
- iv) Dough stage (85 - 90 DAS)

In wheat time of irrigation is more important than the number of irrigations.

- Irrigation may be given when ASM reaches 40-50 %.
- Irrigation at CRI is very necessary as this stage is the most critical for irrigation.
- Since the rooting depth at early stages is very shallow (15-25cm), initial irrigations should be given with less amount of water (4-5cm / irrigation), later irrigations should be given with sufficient water (6-7 cm / irrigation).

4.6 Harvesting

It varies from time to time and zone to zone; growing conditions. Rainfed crop reaches maturity earlier than irrigated.

4.7 Maturity symptoms

The crop is harvested when the grains harden and the straw becomes dry. Don't allow the crop till it is dead ripe. Harvest the crop while base of the stalks lightly green to avoid shedding. Non shedding varieties they are harvested when the grain is matured fully. The most suitable stage is when the grains become hard & contain 20-25% moisture.

4.8 Yield

- Irrigated conditions : 45-55 q/ha
- Rainfed conditions : 20-25 q/ha
- Grain : straw ratio = 1:2

By adopting improved technology, the crop may yield 5-6 t grain and 7-8 t straw/ha from dwarf wheat varieties under irrigated conditions. Under rainfed conditions 2-2.5 t grain and 3-3.5 t

straw/ha may be obtained. Deshi tall wheat varieties usually give 2-3 t grain and 6-7 t straw/ha may be obtained.

4.9 Storage

The grain should be thoroughly dried before storage. The storage life of grain is closely related to its moisture content. Grains with less than 10% moisture are ideal. In Eastern India, the storage of wheat grains without losing viability for the next crop is a big problem due to high humidity prevailing in that area.

4.10 Product utilisation:

1. Wheat is ground to prepare flour which is mainly consumed after preparing leavened bread i.e. chapathi (cellular spongy like structure due to the presence of GLUTIN).
2. Its flour is also used to prepare chapathis called PURIS or PARTHAS etc.,
3. One of the most important uses of wheat is to manufacture flour to prepare bread, pastry and biscuits.
4. Varieties of Durum wheat having large white kernels are often used for puffing.
5. Wheat straw makes an important fodder.
6. By-products of wheat flour mills particularly bran are used as cattle feed.
7. Among the industrial uses of wheat, the production of starch for the paper industry is important.

Lecture 5

5.1 Barley

Scientific name: *Hordeum vulgare*

Family: Poaceae

It is the most important cereal grain crop after rice, wheat and maize. In India the crop is cultivated as summer crop in temperate regions and as a winter crop in tropical regions. It is a good drought tolerant crop. It is mainly used as live-stock feed and in now a days it is used for human consumption (barley malt). Generally, barley is cultivated as Rabi season crop in India. Used as food, forage, feed, malt and fuel

5.2 Origin:

Barley is believed to be originated from in Abyssinia (Ethiopia) and south-east Asia.

5.2.1 Producing countries: USSR, Canada, France, Spain, UK, Germany, Australia

Producing states: Rajasthan, U.P, M.P, Harayana, Punjab, West Bengal. J&K, Bihar, etc.,

Local names: Barley (English, Telugu, Kanada, Malyalam), Sattu (Marathi), Jau (Hindi)

5.3 Classification

Aberg and Wiebe (1946) classified all the cultivated barley varieties into three distinct species based on the number of rows of grain and their arrangement:

- (a) *Hordeum vulgare*-six-row barley
- (b) *Hordeum distichon*-two-row barley
- (c) *Hordeum irregular*-two-row barley

a. *Hordeum Vulgare*: In this species all the three spikelets at each node of the spike are fertile. The spikelets are in six distinct rows and arranged at a uniform distance around the tough rachis. This species is cultivated In India.

b. *Hordeum Distichon*: In this species only the medium spikelets are fertile and sets grain. Although the lateral spikelets are infertile, they possess all the floral organs. This species is also cultivated in India.

c. *Hordeum Irregulare*: In this species central florets are fertile, when, the lateral florets are reduced to rachilla.

5.4 Botanical description

Barley (*Hordeum spp.*) belongs to *Gramineae* family. The barley plant very much resembles the wheat plant and usually grows 0.75 to 1 metre in height. The botanical description of main parts of barley plant is given below:

5.4.1 Root System

It consists of shallow and deep roots. The shallow roots arise near the soil surface and spread out laterally about 15-30 centimetre almost at right angles to the tillers. The deep roots extend downwards into deep layers of soil. The depth of penetration varies from 0.75 to 150 cm.

5.4.2 Stem (Culm)

The stem is cylindrical and possesses five to seven hollow internodes separated by solid nodes, at which the leaves arise. The internodes are short at the base of the plant and the length increases from the base of the culm upwards. The nodes may be either exposed or hidden by the sheath depending on the kind of barley variety. The usual number of tillers per plant varies from two to five.

5.4.3 Leaves

Leaves arise from nodes of the stem and are borne alternately on opposite sides of the stem. Each leaf consists of a sheath, blade, ligule and auricle. The leaves of barley are usually broader and of lighter green colour than wheat. The leaf sheath is generally glabrous, but in a few varieties it is covered with hairs. The leaf blade is lanceolate linear. They possess small ligule (0.5 to 3 millimetre). Auricles are very conspicuous, which partly or entirely clasp the stem and are much larger than those in wheat. The surface of leaf is rough. Two-rowed barleys have narrower leaves than six-rowed barleys.

5.4.4 Inflorescence

The inflorescence is called spike or head. The spike at the top of the stem consists of spikelets attached at the nodes of a zigzag rachis. Each spikelet has two glumes and a floret. Three spikelets are attached at each node of the rachis. In two-rowed barleys only the central spikelet is fertile,

whereas in six-rowed barleys all the three spikelets are fertile. The rachis is tough in all cultivated varieties of barley. Each barley spikelet has two glumes which terminate in an awn that may be shorter or several times longer than the glume itself. The length of the glume awn is a very useful character of distinguishing varieties. The barley flower has three stamens, and a pistil with a single ovule and a stigma. The lodicules are present at the base of pistil and serve to open the flower by swelling during pollination. Barley is a normally self-pollinated crop.

5.4.5 Kernel (Grain)

The grain of barley is a caryopsis consisting of lemma, palea and a rachilla. In most of the barley varieties the lemma and palea adhere to the caryopsis, whereas in others (naked barley) they are free and the caryopsis threshes out like wheat. The caryopsis is composed of the pericarp, endosperm and embryo.

5.5 Cropping systems

Barley being a short duration crop is more suitable than wheat and other cereal crops for late sown conditions under limited inputs of irrigation and fertilisers. The crop can be grown successfully after the harvest of paddy, cotton, *Kharif* fodder, groundnut etc. Barley is included in following common cropping systems.

1. Rice-barley
2. Maize-barley
3. Sorghum-barley
4. Cotton-barley
5. Pearl millet-barley
6. Groundnut-barley
7. Blackgram-barley
8. Moong-barley
9. Cowpea-barley
10. Clusterbean (Guar)--barley

Barley is grown mixed with crops like chick pea, mustard, linseed etc.

5.6 Soils

- It is grown successfully on all the soils where wheat can be grown.
- Good drained soils are good.
- PH range is – 6.5-7.8
- It is more tolerant than other cereal crops in alkaline soils and less tolerant to acid soils.

5.7 Temperature

- Barley will germinate at temperature of 2⁰ C but emergence is low at this temperature. Barley crop is grown as summer and winter crop, but the main crop is in rabi season.
- It requires temperature of 12-16⁰C at growing stage and 30-32⁰C at ripening stage.

Lecture 6

6.1 Land preparation

- Land should be prepared to fine tilth stage and weed free by giving 2-3 ploughing's with cultivator followed by planking.
- Seed treatment is advisable in barley to prevent smut.
- Treat the seeds with bavistin @2 gm/ kg seed, vitavax 2.5 gm per kg seed.

- 250 ml formathion in 5 litres water for 100kg seed- termites

6.2 Methods of sowing:

Seed drill, is more effective

6.3 Sowing time

Mid- October to mid- November – irrigated. 2nd fortnight of October – rainfed .1st fortnight of January- if sown after *kharif* rice.

| Seeding time | Seed rate (kg/ha) | Time of sowing | Spacing | Seeding depth |
|-----------------------|--------------------|----------------|-----------|---------------|
| Irrigated timely sown | 75-80 | 10-25 nov | 20-22.5 | 4-5cm |
| Late sown irrigated | 100 | 25 nov -15 dec | 15-20 | 4-5 cm |
| Rainfed timely sown | 80-100 | 15 -30 oct | 22.5-28.5 | 5-7cm |

6.4 Fertilizer and manures

Manures and fertilizers both play important roles in barley cultivation. When barley is grown as an irrigated crop, about 10-15 tonnes of compost or farm yard manure could be applied about a month before sowing.

| situation | N (Kg/ha) | P(Kg/ha) basal | K (Kg/ha) basal |
|-------------------|-----------|----------------|-----------------|
| irrigated | 60 | 30 | 30 |
| Rainfed (hills) | 40 | 20 | 20 |
| Rainfed (plains) | 30 | 30 | 20 |
| Saline soils | 60 | 30 | 30 |
| Malt barley | 80 | 40 | 30 |

6.5 Weed control

2, 4-D sodium salt (80 per cent) or 2, 4-D amine salt (72 per cent) at 0.75 kg a.i. per hectare in 700-800 litres of water per hectare, 35-40 days after sowing of the crop. Under rainfed conditions the rate of herbicide should be slightly lower, i.e., 0.5 kg a.i. per hectare. For the control of *Phalaris* minor and wild *Qat* (*Avena fatua*) spray Isoproturan 75 WP at the rate of 1.0 kg a.i./ha or Pendimethalin (stomp) 30 EC at the rate of 3.3 litres in 600-800 litres of water 2-3 days after sowing.

6.6 Disease

6.6.1 Molya Disease of Barley

This disease is caused by a nematode *Heterodera avanae*. It occurs in small patches. Due to this disease plants are stunted in growth, leaves are discoloured to yellow and often become reddish from the tip. Tillering is also reduced. The growing point of root is inhibited and often killed. The plants produce new roots near this point causing a rosetting effect.

6.6.1.1 Control measures

- (a) Adopt crop rotations of three to four years with non-cereal crops.
- (b) Two or three deep ploughings during summer will also reduce the nematode population. '
- (c) Grow resistant varieties like RD-2035, Karan-16 etc.

6.7 Insect pests

Barley crop is attacked by a number of insect pests and rodents. Some of the most important and common ones are given below:

6.7.1 Soil Insects

There are a number of soil insects that damage the crop soon after sowing. The damaged plants dry up completely causing poor crop stand. The important soil insects are white ants (*Odonto terms obesus*) termites (*Microtermes indicus*), Gujhia weevil (*Benymercus indicus*) and cutworms (*Agrotis* spp.). For the control of these insects use 2% Methyl parathion or 5% Malathion dust at the rate of 20-25 kg per hectare and mix it well in the soil at the time of last ploughing before sowing.

6.7.2 Foliage Pests

Aphids are serious pests in humid regions. They are green to dark coloured small insects. These insects cluster in large numbers and suck the sap from leaves, stem etc. They also spread disease 'barley yellow dwarf' transmitting the virus. These insects can be controlled by spraying Oxydemeton methyl (Metasystox) 25 EC or Dimethoate (Rogor) 30 EC at the rate of 1.0 litre in 1000 litres of water per hectare. Repeat the spray at 10-15 days interval.

6.7.3 Rodents

Field rats cause heavy loss to barley crop and do considerable damage to the harvested crops lying in stacks in the field. For rat control fumigate live-burrows with aluminium phosphide at the rate of one tablet of 0.5 g per small burrow, and 3.0 g per large burrow. In case of reappearance in the same field, bait with Cumarin (Ratafin) at the rate of 1 kg of prepared bait (1 part Cumarin: 19 parts wheat or maize flour, 1 part molasses and 1 part mustard oil).

6.8 Water management

The total water requirement is 20-30 cm water. Critical stages for irrigation are

Active Tillering: 30-35 DAS

Flag leaf/ booting: 60-65 DAS

Milk/ grain filling: 80-85 DAS

6.9 Harvesting and threshing

The crop should be harvested immediately after it ripens otherwise it might lodge and shatter grains. This crop shatters more easily than does wheat. It should be harvested in the foreman before the heads become too dry and fragile for handling. Harvesting of crop is done with sickle by manual labour. Threshing is done either by trampling buttocks or by stationary threshers.

6.10 Yield

When cultivation of high yielding varieties of barley is done with improved scientific methods, they produce about 30-35 quintals of grain and 40-45 quintals of straw per hectare. The malting process converts raw grain into malt. The malt is mainly used for brewing or whiskey/ beer making, but can also be used to make malt vinegar or malt extract. Various grains are malted, the most common grains used are barley, sorghum, wheat

Lecture 7

7.1 PULSES – IMPORTANCE OF PULSES IN INDIAN AGRICULTURE:

Pulse crops called grain legumes are the most important food crops after cereals. They have been valued as food, fodder and feed and have remained as main stay of Indian agriculture. The term pulse is derived from the latin word “Puls” meaning “pottage” (thick soup). Pulse crops play an important role in agricultural economy of India. They fix atmospheric nitrogen and their deep penetrating root system enable the plants to utilize limited available moisture more efficiently. Indian Institute of Pulse Research (IIPR) was established in 1993 at Kanpur. Per capita requirement of Pulses: Acc. To ICMR – 150gm /day and Acc. To FAO – 140gm /day. At present, the per capita availability of pulses in India is only 47gm/day.

7.2 Area, production and productivity of pulses in India

Pulses are grown over an area of 23 million ha with a production of 13 to 14 million tonnes with average productivity levels ranging from 500-600 Kg/ha. India accounts for 33% of total world area under pulses and 25% of total world production. Kharif pulses (Pigeon pea, black gram, green gram, horse gram, Moth bean, Cowpea) cover 45% of total area and 30% of total pulse production. Rabi pulses (Chick pea, pea, lentil, and lathyrus) cover 55% of total area and 64% of production. Major pulse producing states are Madhya Pradesh, Maharashtra, Orissa, Rajasthan and Uttar Pradesh. Highest production of pulses is from Madhya Pradesh followed by Rajasthan and Uttar Pradesh.

7.3 Importance of Pulses:

They are rich source of proteins Vitamins, an average protein available in pulses is 20-30%. Pulses are rich in ‘Ca’, Phosphorous. Pulses provide a superior quality of fodder & feed to the cattle, as they are good forage crops with proteins and minerals content and considered as good green manure crops because of rich canopy development. They improve the soil fertility by biological nitrogen fixation due to this, the nitrogen needs of pulses is low & minimizes the N requirement of

succeeding crop by around $\frac{1}{4}$ of its total requirement. Pulses help in the Soil and Water conservation and improves the physical condition of the soil like soil aeration, water holding capacity by improving microbial population, breaking of hard pans and moisture retention. Some crops act as smothering crops which control weeds & protects soil from erosion. E.g.:- Cowpea and Horse gram. Pulses can also be used better intercrops.

7.4 Pulses-reasons for low yields of pulses in India

7.4.1 Agronomic constraints:

1. **Improper sowing time:** time of sowing is very important to protect from diseases and pest.
2. **Low seed rate:** Farmers have been using a seed rate of 10-15 kg/ha as against the requirement of 20- 25 kg/ha in case of moong.
3. **Defective method of sowing:** Pulses are hardly sown in rows. This creates lot of problems in adopting agronomic practices such as weeding, hoeing, spraying, harvesting etc.,
4. **Inadequate interculture:**
5. **Insufficient irrigation:** Though pulse crops are drought tolerant, one or two protective or lifesaving irrigations are required, particularly in Rabi pulses. For Kharif pulses also, protective irrigations are essential during the period of dry spell.
6. **Sowing under utera cultivation:** Large area under pulses is sown as utera without cultivation and inputs. The yields of such crops is very poor.
7. **Weed infestation:** Because of their inherent slow growth rate at the initial stage, pulse crops suffer due to infestation of weeds. Depending upon the duration of the crop, the critical period for weed competition in the pulses varies from 20-45 DAS. If weeds are not controlled during this period, marked crop losses ranging from 30-50% in chick pea, 50-70% in green gram and black gram and as high as 90% in pigeon pea have been recorded.
8. **Losses due to diseases and insects pests:** The major diseases are wilt, blight and grey-mould in chickpea. Powdery mildew and leaf spot diseases in green gram, black gram and cowpea etc.

7.4.2 Genetical constraints:

1. Lower productivity.
2. Non synchronous fruiting/ flowering.
3. Non-responsiveness to good management.
4. Complete or partial absence of genetic resistance to major diseases and pests (eg: *Helicoverpa armigera* under continuous rainfall, causes wilt and sterility mosaic in red gram etc.).
5. Indeterminate growth habit of most of the pulses Instability in performance.
6. Non-availability of drought and waterlogging resistant varieties.

7.4.3 Physiological constraints:

1. Low harvest index.
2. Flower drop is another physiological problem in pulse crops. This results in poor pod setting and consequently low yield.
3. Non-responsiveness to fertilizers.

4. Photo and thermo sensitive phenomenon.
5. Lack of short duration varieties i.e. long duration gives low per day production.

| Common name | Botanical name | Common indian name |
|------------------------|---------------------------|--------------------|
| Chickpea or bengalgram | <i>Cicer arietinum</i> | Chana |
| Pigeon pea or redgram | <i>Cajanus cajan</i> | Arhar |
| Greengram or mungbean | <i>Phaseolus aureus</i> | Mung |
| Blackgram or urdbean | <i>Phaseolus mung</i> | Urd |
| Cowpea | <i>Vigna unguiculata</i> | Lobia |
| Lentil | <i>Lens culinaris</i> | Masoor |
| Mothbean | <i>Vigna acontifolia</i> | Moth |
| Horsegram | <i>Dolichos biflorus</i> | Kulthi |
| Lab-lab | <i>Dolichos lab-lab</i> | Urabi |
| Beans | <i>Phaseolus vulgaris</i> | Rajmash |
| Garden pea or pea | <i>Pisum sativum</i> | mutter |

Lecture 8

8.1 BENGALGRAM/CHICK PEA

Scientific name: *Cicer arietinum*

Family: Leguminaceae

8.2 Origin: Western Asia (Turkey)

8.3 Economic importance:

Chick pea contains 21% protein, 2.2% fat, 62% carbohydrates. It also contains calcium of about 190 mg/100g; Iron 90.5 mg/100g; Phosphorus 280 mg/100g. Among the pulses, chick pea has relatively lower protein content but of higher biological value and protein digestibility. Germinated seeds can cure scurvy. An acid liquid from the granular hairs of leaves and pods contains two acids. They are i) Malic Acid (90-96%) ii) Oxalic Acid (4-10%). Which are used in the preparation of drugs, and are prescribed for the intestinal disorders and blood purification. Soaked seed and husk are fed to cattle.

8.4 Area, Production, productivity:

It is also known as Gram (or Chana). On the basis of the cultivated area, chick pea is the 19th most crop grown in the world. 77% of total area and production in world is from India. Important countries growing chick pea are Pakistan, India, Turkey, Mexico, Burma, and Ethiopia. In India –

Madhya Pradesh ranks first in Area (2.6 m.ha), production (2.4 m.t) with a productivity of 930 kg/ha followed by Rajasthan. The three states Madhya Pradesh, Rajasthan, Uttar Pradesh accounts for 84% of Area, 86% production in the country.

8.5 Climate:

It is a Rabi pulse crop and requires cool humid weather and mainly suitable to North India. It is suited for moderate rainfall areas of 400-700mm. Water-logging results into wilt diseases (when grown with Red gram), Optimum temperature regime for chick pea is 24-30°C. Chick pea is a long day plant and requires sufficient bright sunshine. The period of cool temperature decides the duration of the crop, because of which in North India, it comes to harvest in 160-170 days. Where-as the winter is warm in South India then the duration is shorter of about 90-110 days.

8.6 Soil:

It can grow on wide range of soils from medium to heavy black soils. It does well on Black cotton soils and sandy loams. Optimum pH required for crop growth is 6.0 to 7.5 (>8.5pH not suitable). It does not withstand water -logging, saline and alkaline conditions

8.7 Types and Varieties in Chickpea:

- There are 2 important varietal types available in India They are:
- 1) Kabuli type 2) Desi type.
- Mostly cultivated type of chick pea is Desi type.

Difference between Desi type and Kabuli type

| CHARACTERS | DESI TYPE | KABULI TYPE |
|--------------------------|--|----------------------------|
| Area undercultivation | More area | Less Area |
| Color of the seed | Yellow to dark brown | White (or) Pale cream |
| Size of the seed | Small | Large ,bold and attractive |
| Shape of the seed | Irregular and wrinkled | Smooth |
| Plant structure | Small and bushy | Taller and erect. |
| Percentage of production | 85% | 15% |
| Yield potential | High yielders | Low yielders |
| Adaptation | Mostly to winter climates | Mostly to spring |
| Test weight | 17-26 gm /100seed | >26 gm /100 seeds |
| varieties | Jyothi (ANGRAU); Annegivil (Karnataka) | Kranthi, Swetha |

- Other varieties: Radhay, Gwalior, Vikas, Chabba
- Wilt tolerant variety: Vishal, Vijay, Avarodhi
- Popular varieties grown in A.P: Annegiri, Kiranthy, Jyothi, Swetha

8.8 Varieties:

8.8.1 Desi type: Avrodhi, pant G- 186, gaurav, uday, Radhey, pusa -256, pusa-362, harayana chana -1, Gora hiasri.

8.8.2 Kabuli type:C-104, L-550, L-144, Pusa-1003, sadabahar.

8.8.3 Field preparation:

- Rough seed bed is required for chickpea.
- In case chick pea crop is taken after *kharif* fallow, deep ploughing is desirable.

8.9 Seeds & Sowing:

Seed rate:

- Desi Type 65-70 kg/ha
- Kabuli type 80-90 kg/ha
- Early sowing of chickpea results in excessive vegetative growth and poor setting of pods. The early sown crop suffers more from wilt. Seed treatment with thiram or carbendazim 0.25 % before sowing should be done.

8.10 Spacing:

- Desi type 30x10cm.
- Kabuli type 45x10cm.

8.11 Time of sowing: Middle October to first fortnight of November.

8.12 Depth of sowing: the depth for the chickpea is 6-8 cm. If delayed, sowing of chick pea results in possibility of effecting wilt diseases. Early sowing results in excessive, vegetative growth and poor setting of pods.

| Seeding time | Seed rate (kg/ha) | Spacing (cm) | remarks |
|---|---|--------------------------------|---|
| N-India : October 3 rd week Central and peninsular region : early October | Rain fed traditional = 65-70 Rain fed irrigated kabuli = 80-90 | 30 cm (desi) 45 cm (kabuli) | Drilling or furrow sowing to a depth of 8-10 cm for rain fed and 5-7 cm for irrigated |

8.13 Fertilizers and manures:

Total Fym to be applied is 10 t/ha

| Situation | N (Kg/ha) | P(Kg/ha) basal | K (Kg/ha) basal |
|-----------|-----------|----------------|-----------------|
| Rain fed | 10 | 40 | 20 |
| Irrigated | 20 | 60 | 40 |

- Zn deficiency can be corrected by 0.5% ZnSO₄. Spray or soil application of 25kg /ha Zinc Sulphate which is effective in increasing the yields.
- Bio-fertilizers: Seed treatment with the Rhizobium strain namely cicer rhizobium will increase the Nitrogen fixing ability of the plant and thereby yield will be enhanced by 20-30%.

Lecture 9

9.1 Irrigation:

55% area of chickpea is under Rain fed. Where under drought conditions, the crop requires 2 irrigations at critical stages.

- 1) at Branching (45 DAS) and
- 2) at pod formation (75 DAS)

If water is adequate then four irrigations are recommended at:

- 1) Sowing
- 2) Branching
- 3) Flowering
- 4) Pod filling

Evaporative demand is high in South India, Irrigation at that time can double the yield, evaporative demand is low in North India, and Irrigation can cause excessive growth leading to lodging.

9.2 Critical stages:

- Branching – 45 DAS
- Pod formation – 75 DAS
- Depending on soil type water requirement range is **300-400mm**
- Very sensitive to soil salinity.

9.3 Weed control:

Weeds become problematic in chickpea due to its short growing nature. Weeds are found more under rain fed condition. First 40 DAS are critical for weed competition.

9.3.1 Pre-emergence herbicides are

- Bentazon (1.0-1.5 kg/ha)
- Pendimethalin (0.5-1.0 a.i kg/ha)
- Pendimethalin (0.5%) + Imazethpyr (50g)

9.3.2 Pre-plant incorporation of

- Fluchloralin (0.5 – 1.0 a.i kg/ha)
 - Trifluralin (0.5-0.7%).
- 2 or 3 timely intercultivations for row sown crop.

9.4 Harvesting:

In **North India** chickpea duration is **150-160 days**. In **South India** crop comes to harvesting within **90-110 days**. Crop is harvested when leaf turns to reddish brown and starts leaf

shedding. Harvesting is done during morning to avoid shattering of pods. Plants are pulled out or cut with a sickle and carried to threshing floor.

9.5 Threshing:

The harvested plants are dried in sun for about a week and then it is threshed under the feet of cattle (or) by beating with sticks. Then the grain is collected and it can be used directly (or) crushed.

9.6 Cropping systems:

Rice – Chick pea

Cotton – chickpea

9.7 Intercropping:

Chick pea + Mustard

Chick pea + Linseed

Chick pea + Sunflower

Chick pea + Coriander (for South zone)

9.8 Yield: The yield of chickpea is 20-25 q/ha.

9.9 Collection of acids from chick pea crop:

The leaves and pods of Bengal gram on the growing crop are coated with thin film of **Malic acid (90-96%)**; **oxalic acid (4-9%)**. They are encrusted on leaves and pods and dissolved on dew and settles on plants during winter season due to this the plants give sour taste. These Acids are considered to have some medicinal properties and they may be collected and stored. About 4 – 4½ kg of acids may be obtained from 1 ha of crop.

Lecture 10

10.1 LENTIL

Scientific name: *Lens culinaris/ Lens esculanta*

Family: Papilionaceae

The fourth most important pulse crop of the world. Globally it shares 5% of pulse area.

10.2 Origin: Central Asia (India, Pakistan)

Two types of lentils

Masur/ Malkamasur – large seeded – Africa, Central Asia

Masuri – small seeded- India, Pakistan, south and west Asia.

Major lentil producing countries: Canada (39%), Turkey, India, USA, Ethiopia, Syria

- Highest yield : Egypt, USA
- Diploid species: $2n = 14$

10.3 Area and distribution of lentil in india

Area: 1479 thousand ha, and Production: 1031 thousand, Yield: 697 kg/ha Important states: UP, MP, Bihar, West Bengal. UP and MP produces 70% of national production. Highest productivity: 911 kg / ha in West Bengal

10.4 Economic Uses of Lentil

- It is mostly grown as pulse and used in the form of dal.
- Seeds are roasted and eaten. Roasted seeds are sometimes used as an ingredient for table snacks.
- Protein content is about 24-26% which is more than Tur, Urad, Mung and Gram.
- It contains 1.3% fat, 3.2% fiber, 2.2% minerals and 57% carbohydrate. Rich in calcium, iron and niacin.
- Unripe pods are used as vegetable.
- Dried husk, stalks and broken grain is used as cattle feed.
- In Kashmir valley, it is grown for green manuring in paddy
- It is used as cover crop to control soil erosion.

10.5 Climate

Cool season (Rabi) crop, Opt. temp 18-30 °C. Tolerant to frost and severe winter to a greater extent. Moderately tolerant to acidity and alkalinity. Sensitive to water logging. Requires cool temperature during vegetative stage and warm temperature during maturity.

10.6 Agro techniques

Ploughing followed by 1 or 2 harrowing is adequate. In heavy soils 1 deep ploughing followed by 2-3 harrowing's should be given. In light soils, less tillage is needed to prepare an ideal seedbed. Seed rate: 40-50 kg/ha

10.7 Varieties

JL 1, VL Masoor 4, Sapna (LH 84-8), L 4076, Salimar mashur 1, Pusa lentil 4, Priya (DPL 15), Pusa vibhav, Sapna, Subrata, Mallika, Sapana, Garima, WBL-58, Sheri, Narendra Masoor, Pant Lentil 5, Noori, Asha, Ranjan, Jawahar Lentil-3, Pant L5, Pant L 6.

10.8 Cropping systems

Rice-lentil
Maize –lentil
Cotton –lentil
Sorghum- lentil,
Groundnut – lentil

10.9 Time of sowing

Middle of October is the most suitable time for sowing. Delay in seeding causes reduction in yield the rate of reduction can be minimized by relatively closer spacing and use of higher seed rate. The magnitude of delayed sowing and yield loss is large after mid November. Sowing should be done at shallow depth of 3-4 cm. Seeds should be treated by fungicides and after one week inoculated by Rhizobium bio-fertilizer.

10.10 Spacing

- Bold seeded: 50 kg/ha with spacing 30cm x10 cm
- Small seeded: 30 kg/ha at spacing of 30cm x5 cm.
- Late sown small seeded: 40kg/ha; 20cm x 5 cm.

10.11 Nutrient management

The application of 5-15 t/ha FYM is beneficial. 20-30kg N ; 50-60 kg P₂O₅/ha, 25 kg /ha of ZnSO₄ will meet the needs Zn for lentil crop. the foliar application of 0.5 % ZnSO₄ can correct the zinc deficiency.

10.12 Water management

Lentil crop is mostly sown under unirrigated conditions. It can tolerate drought to some extent, 15 cm water is sufficient. By giving 1 or 2 irrigations when winter rains are not properly distributed, higher yields can be obtained. 1st irrigation should be given at 45 DAS and 2nd if needed at pod filling stage. More irrigation may adversely affect crop performance.

10.13 Weed management

First 30-60 DAS is the critical period for weed competition. Major weeds are *Chenopodium album* (bathua), *Melilotus alba* (senji), *Cirsium arvense* (Kateli). Hand weeding at 25-30 and 45-50 DAS is to be done. Pre emergence herbicides such as pendimethalin, fluchloralin can effectively control the weeds.

10.14 Harvesting

Masur crop become ready for harvesting within 100 to 120 days after sowing. It is harvested by cutting the plants near to the ground before it is dead ripe. The plants are dried in sun for one week on threshing floor. Threshing is done by beating the plants with stick and winnowed to clean off seed from chaff. The green pods are picked for vegetable purpose.

10.15 Yield: the yield of lentil is nearly 20-25q/ha.

Lecture 11

FIELD PEA

Scientific Name: *Pisum Sativum*

Family: Leguminaceae

Local name: Matar

11.1 Origin: Southern Europe and West Asia

11.2 Economic uses of pea

1. Green pods of peas are fried with salt and seeds are eaten.
2. Matured seeds are used as vegetable or mixed in other food articles like pulav, mixed vegetables etc.
3. Husk and grinded seeds are fed to cattle.
4. Used as Dal in India
5. Green Peas are canned, frozen and de-hydrated.
6. It is also grown as mixed crop with oat and used as a fodder.

11.3 Composition of 100g dried seed/grain

| | |
|--------------|---------|
| Protein | 22.5 g |
| Fat | 1.8 g |
| Carbohydrate | 62.1 g |
| Ca | 64 mg |
| Iron | 4.8 mg |
| Riboflavin | 0.15 mg |
| Thimin | 0.72 mg |
| Niacin | 2.4 mg |
| Moisture | 11g |

11.4 Area and distribution

Pea growing countries are China, India, Ethiopia and USA. Globally it is cultivated in 6.18 mha of area with a production of 10.48 mt. China ranks 1st in area and production of pea. In India UP ranks first in area, production. UP, MP, and Bihar are the major pea producing states. In India, 0.76 mha area is cultivated with a production of 0.67 mt. Productivity in India is 866 kg ha⁻¹

11.5 Classification

Two types of pea are generally cultivated all over the globe.

- Garden pea (*Pisum sativum var. hortense*)
- Field pea (*Pisum sativum var. arvense*)

They are also grown as forage or green manure crop. They are hardy plants and grown without irrigation.

11.5.1 Difference between garden pea and field pea

| Garden pea / Table pea | Field pea |
|--|---|
| Young green seeds are mostly used in vegetables and for canning. | Mature seeds are used as pulse. |
| Seeds are bold and wrinkled. | Seeds are round and little angular. |
| White flowered. | Generally flowered. Many colors |
| Seeds are yellowish, whitish or green. | Seeds are greyish green, greyish brown or greyish yellow. |

11.6 Climatic requirement for cultivation of pea

Pea is a cool and dry season crop. For germination, about 22⁰C temperature is considered favorable. High temperatures are more injurious to pea crop than frosts. Optimum monthly temperature suitable for growth is 13-18⁰C.

11.7 Soil requirement for cultivation of pea

Pea crop can be grown in medium to heavy soils. It grows best in well drained loose heavy soil. It cannot be grown in alkaline soils. Optimum pH 6.5-7.5, highly sensitive to water logging.

11.8 Varieties of field pea

JP 885, Sikha (KFP 103), Alankar (DMR 7), Uttara (HFP 8909), Swapna (KPMR 144-1), Jayanti (HFP 8712), Malviya Matar (HUDP 15), Swati (KFPD 24), Pusa Prabhat, Ambika, Pusa Pana (DDR 27), KPMR 400 (Indra), KPMR 522 (Jay), Subhra (IM 9101), IPF 99-25 (Adarsh), Pant Pea 14, VL 45, IPFD 99-13 (Vikash), Pant Pea 13, IPFD 10 (Prakash), Pant Pea 25, Pant Pea 42, HPP 9426, Pant P 74, IPF 5-19, TRCP 8

11.9 Cropping systems

- Maize – Field pea
- Rice – Field pea
- Cotton – Field pea
- Sorghum – Field pea
- Pearl millet – Field pea

11.10 Seeds and sowing

Second fortnight of October is the optimum time for sowing of field peas in North India - Field pea. First fortnight of November is the optimum time for sowing of field peas in North India - Garden pea. Sowing after October results in reduction in yields. Seed rate: 60-80 kg/ha, spacing: 30 X 10 cm. Seed treatment with Thiram or Carbendazim @ 2.5 g/kg of seed before sowing. Inoculation of seed with Rhizobium (7 days after chemical fertilizer)

11.11 Nutrient management

The application of FYM is 5-15 t/ha and RDF is 20-30: 60-70: 30-40 N: P₂O₅:K₂O Kg/ha.

11.12 Water management

Crop is mostly grown under un-irrigated areas. It can tolerate drought condition to some extent. 1st irrigation should be given at 45 DAS and 2nd at pod filling stage. Light and uniform irrigation should be given. Water logging conditions leads to considerable loss in the yield since this crop is highly sensitive to poor drainage conditions. Poor drainage leads to reduction in number of branches and pods per plant.

11.13 Weed management

Critical period for weed competition is 35-50 DAS, Later on crop itself checks the growth of weeds. Major weeds are Chenopodium album, Lathyrus spp, Melilotus alba. Weedicides like fluchloralin, (0.75 kg/ha in 800-1000 liters of water) and tribenuron may be used.

11.14 Important pests of pea

Pod borer, Aphids, Leaf miner

11.15 Important diseases of pea

Powdery mildew, Wilt and Root rot, Rust

11.16 Harvesting

Pod becomes ready for harvesting in about 100 to 120 days after sowing. Green pods are harvested results in reduction of market value. Delayed harvesting results in reduction of market value. Pods are hand-picked. Harvesting is done 3 to 4 times during the season. For matured grains harvesting is done when leaves begins to turn yellow.

11.17 Yield

The average yield is 800 to 1000 kg/ha.

Lecture 12

12.1 OILSEEDS – Importance of oilseeds in Indian agriculture

- the crops that are cultivated for the production of oils are known as oilseed crops.
- Oilseeds are the raw materials for vegetable oils and they are energy rich crops.
- Oilseed crops are the most important commercial crops in India.
- The Rapeseed and Mustard, Sesamum, Sunflower, Safflower, Linseed, Soybean, Niger, Groundnut and Castor are the most important oil seed crops of India.

12.2 Classification

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

12.2.1 Edible oilseed crops:-

- The most important source of supply of edible oils are the seeds known as edible oil.
- E.g., Rapeseed & mustard, sesamum, groundnut, Niger, sunflower, safflower, soybean etc.

12.2.2 Non-edible oil seed crops:-

- The most important source of supply of non-edible oils are the seeds known as non-edible
- E.g., Castor, Linseed etc.

12.3 Nutritional value of oilseeds:-

- The bio-chemical composition and quality of the oilseeds and their products are important for the food and feed purposes.
- Edible oils are the concentrated sources of energy. The energy content of oil is much higher (39.80 MJ/kg) than protein (23.88 MJ/kg) or carbohydrate (16.76 MJ/kg).
- They contain useful carbohydrates, essential fatty acids and vitamins A,D,E and K and provide essential fatty acids.
- Oil cakes/ oil meals are rich sources of protein (40-60%) to human and animals. They can also be used as organic manures.
- Oil quality for food purpose can be described in terms of Saturated Fatty Acid (SFA), Monounsaturated Fatty Acid (MUFA) and Poly Unsaturated Fatty Acid (PUFA).
- Saturated Fatty Acid (SFA) - Palmitic and Stearic acid
- They have direct relation with blood cholesterol and coronary heart diseases as it increases low density lipoprotein that is harmful.
- Unsaturated Fatty Acid (SFA) - Oleic, Linoleic, Linolenic and Erucic acids.
- Linoleic & Linolenic acids (Poly Unsaturated Fatty Acids – PUFA) are Essential fatty acids (not synthesized by human body and are to supplied from outside).

- Groundnut, coconut, sesame and sunflower oils have moderate amounts of saturated fatty acid but lack in one essential fatty acid i.e. linolenic acid.
- Soybean, safflower and mustard oils have both essential fatty acids as Linoleic and Linolenic acids.

12.4 Importance of oil seed in Indian economy

- In terms of vegetable oils, India is the fourth largest oil economy in the World after USA, China and Brazil.
- The oil seeds contain 20 – 60 % oil, which is chiefly consumed as food and energy source. They are energy rich and cash value crops.
- Oil seed crops can serve as pasture, cover and green manure crops. They are also used as fodder and for silage.
- Vegetable oils have medicinal and therapeutic value and also used as laxatives. E.g., Castor, Safflower & Sunflower oil.
- Safflower tea – prevents cardiovascular diseases and gynecological disorders. If consumed daily, it reduces blood pressure.
- Certain oil seed cakes have vermifugal action & it is used for pest control purposes. E.g., Mustard, Castor.
- Vegetable oils and its derivatives are biodegradable and eco-friendly thus they can be used as diesel substitutes.
- The edible oils are used as cooking oil, vanaspati and proteins.

Lecture 13

13.1 RAPESEED & MUSTARD

Scientific name: *Brassica campestris*

Family : Brassicaceae (Cruciferae)

Rapeseed and mustard are the major *Rabioilseed* crops of India. They occupy a prominent place next to groundnut, both in area and production. India is the largest producer of rapeseed and mustard in the world. Rapeseed contributes for 18 % of total oilseeds production of the country. Common names are sarson, rai or raya, toria or lahi. While sarson and toria are generally termed as rapeseeds, rai or raya or laha is termed as mustard. The oil content varies from 37-49%. The seed and oil are used are condition in the preparation of pickles and for flavoring curries and vegetables. Rapeseed oil is used in the manufacture of greases. The oilcake is used as a cattle feed and manure. Green stems and leaves are a good source of green fodder for cattle. The leaves of young plants are used as green vegetables. The pungent smell of Mustard oil is due to a sulphur containing compound named Allyl isothiocyanate ($\text{CH}_2\text{CHCH}_2\text{NCS}$) or 3-Isouthiocyanato-1-propene (IUPAC).

13.2 Origin

Eastern Afghanistan, and adjoining parts of India and Pakistan.

13.3 Area and distribution

India, china, Canada, Pakistan, Sweden are the major producing countries. In India it is cultivated in UP, Rajasthan, MP, Haryana, Punjab, West Bengal, Assam and Bihar. India: Area is 5.80 m ha, Production is 6.28 million t, Yield is 1083kg/ha UP ranks first in productivity. Rajasthan rank first in area and production. These crops are not drought tolerant. They are not tolerant to waterlogging. Toria is more liable to suffer from frost and cold and is therefore, usually sown earlier and harvested before the onset of frost.

13.4 Difference between rapeseed & mustard

| | Rapeseed | Mustard |
|------------------------|---|---------------------------------------|
| Scientific name | <i>Brassica campestris var. sarson and toria.</i> | <i>Brassica juncea - rai or laha.</i> |
| Plant height | Tall 45-150 cm | Short 90-200 cm. |
| Stem | Covered with waxy deposit. | No waxy deposit |
| Leaves | Sessile, glabrous and hairy. | Stalked, broad and pinnatifid |
| Fruits (pods) | Thicker | slender |
| Seed color | yellow or brown | Brown or dark brown. |
| Seed coat | Smooth | Rough |

13.4 CLASSIFICATION OF RAPESEED-MUSTARD

13.4.1 Sorson: International Common Name Indian rape

Brassica campestris var. yellow sorson (yellow sorson)

Brassica campestris var. brown sorson (brown sorson)

Brassica napus (Gobi sorson)

13.4.2 Toria: International Common Name Rape/ Toria

Brassica campestris var. yellow toria

Brassica campestris var. black toria

Eruca sativa (Taramira)

13.4.3 Rai: International Common Name Mustard

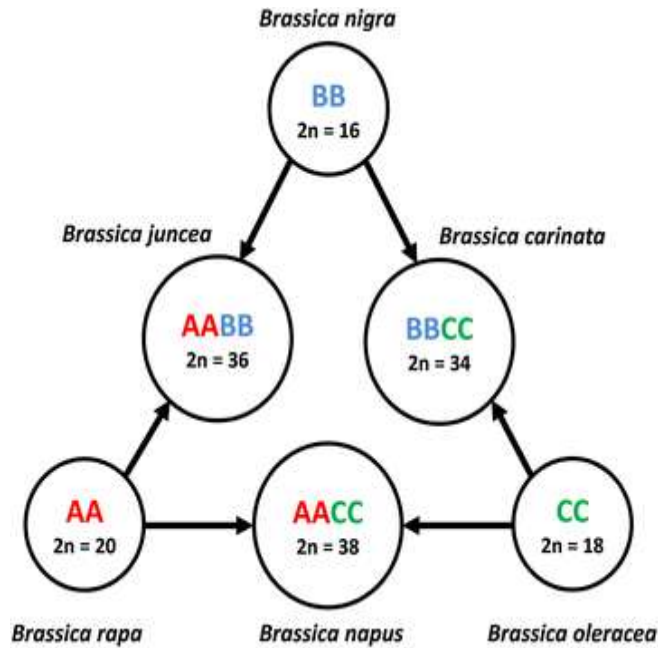
Brassica juncea (Indian mustard)

Brassica carinata (African mustard/ Karan rai)

Brassica juncea var. rugosa (Pahari Rai)

Brassica nigra (Black mustard/ Banarasi rai)

13.5 Triangle of 'U' rule



13.6 Climatic requirement

Rapeseed and mustard crops are of tropical and temperate zones and requires cool and dry weather. Cool temperature, clear dry weather with plentiful of bright sunshine accompanied with adequate soil moisture increase the oil yield. Toria is more liable to suffer from the frost and cold. They are not tolerant to drought and water logging. During sowing: daily mean temperature 26-28⁰C.

13.7 Soil

Grown under soils from sandy loam to clay loam soils but will come best under light loam soils. Moderate tolerant to soil salinity.

13.8 Varieties

13.8.1 Suitable for Kashmir valley, HP

Mustard: RCC4, Pusa Mustard 21

Karan rai: Kiran, Pusa Swarmin

Gobhi sorson: Neelam, Sheetal, GSL 1, GSL 2, Hyola 401(F1)

Jammu, Punjab, Haryana, Delhi and northern Rajasthan

Mustard: RH 30, Pusa Mustard 30, Pusa Mustard 21, Laxmi, CS 52, Geeta, Kanti, Maya, Swaran Jyoti, Vasundhara, Pusa Karishma, DMH 1(F1), Coral 432 (F1)

Karan rai: Kiran, Pusa Swarmin, Pusa Aditya

Gobhi sorson: GSL 1, GSL 2, Hyola 401(F1), PGSH 51, GSC 5, GSC 6

Toria: TL 15, PBT 37

13.8.2 Suitable for West Rajasthan, Uttarakhand, UP, northern MP

Mustard: Jagannath, Varuna, Rohini, Urvashi, Basanti, Narendra Rai, Narendra Ageti Rai 4, Aravali, Swarn Jyoti, Ashirvad, Vasundhara

Karan rai: Kiran, Pusa Swarmin
Gobhi sorson: Teri Uttam Jawahar
Toriam: T 9, Bhawani, PT 303, PT 507, JT 1
Yellow sorson: Ragini, NRCYS 1, YSH 401
Taramira: Narendra Tara (RTM 2002)
Suitable for South Rajasthan, Gujarat, Maharashtra
Mustard: Pusa Jaikisan, GM 2, PCR 7, Shatabdi, TPM 1
Yellow sorson: Ragini, NRCYS 1, YSH 401

Lecture 14

14.1 Suitable for West Bengal, Odisha, Jharkhand, Chattishgarh, Asom, Bihar and Manipur

- Mustard: Pusa Bold, Pusa Agrani, Pusa Bahar, Pusa Sivani, JD 6, Surya, Bhagirathi, Sarama, Varuna
- Toriam: M 27, Agrani, Anuradha, Parvati
- Yellow sorson: Binoy (B 9), Jhumka, Ragini, YSH 401

14.2 Suitable for Karnataka, Tamilnadu, AP

- Mustard: Pusa Agrani, GM 2, JM 1, Vardan, Varuna

14.3 Varieties with abiotic stress tolerance

14.3.1 Drought Tolerant

- Aravali, Geeta, GM 1, PBR 97, Pusa Bahar, Pusa Bold, RH 781, RH 819, Shivani, Vaibhab

14.3.2 High temperature Tolerant

- Ashirwad, Swarn jyoti, Vardan, Navgold, CS 56, Kanti, Urvashi, Pusa Mustard 25, Pusa Mustard 27

14.3.3 Salinity Tolerant

- CS 52, CS 54, Narendra Rai 1

14.3.4 Frost Tolerant

- RH 781, RH 7868, RH 819, RGN 13, RGN 48

14.4 Varieties with pest-disease tolerance

14.4.1 Alternaria blight Tolerant

- Aravali, Geeta, Divya, JMM 915

14.4.2 White rust Tolerant

- Basanti, JM 1, JM 2

14.4.3 Aphids Tolerant

- RH 7846, RH 7847, T 6342

14.5 Cropping systems

- Maize – Toriam - Wheat
- Maize – Toriam – Sugarcane
- Pearl millet – Toriam- Barley
- Maize – Toriam – Cotton
- Green gram – brown or yellow sarson/rai

- Black gram – Sarson / rai
- Maize – Sarson / rai
- Early Rice – Sarson / rai

14.6 Seed and sowing

14.6.1 Time of sowing

- Toria – mid- last week of September.
- Sarson /rai – 1st fortnight of October.
- Late sowing results in attack of aphids.

14.6.2 Seed rate and spacing

- Toria: 30 cm
- Mustard/ Sarson : 40- 45 cm
- Seed treatment with Thiram or Captan @ 2.5 g/kg seed.
- Seed rate : 5-6 kg/ ha

14.7 Nutrient management

The application of 15-20 t/ha FYM and 60-90 kg N ,60 kg P₂O₅ / ha and 40 kg K₂O kg/ha. Under irrigated conditions half of nitrogen and full dose of P and K should be applied as basal dose at the time of sowing. Remaining half N should be applied at the time of 1st irrigation. Rapeseed and mustard have higher requirement for sulphur, therefore nitrogen should preferably be applied through Ammonium Sulphate and phosphorous from SSP. Rapeseed & mustard responds well to Zn and B. Foliar application of micronutrients is beneficial.

14.8 Water management

Usually raised as rainfed on conserved moisture. Rapeseed and mustard responds well to irrigation. Water requirement: 30-40cm. CU: 20-30 cm, two irrigations at branching (30DAS) and siliqua formation (65DAS) stages are beneficial.

14.9 Weed management

Weeds cause 20-30 % yield reduction. Most common weeds are Chenopodium album, Lathyrus spp., Melilotus indica, Argemone mexicana, Cirsium arvense. 1 intercultural operation is beneficial. This besides creating a soil mulch and thus reducing moisture losses through evaporation helps in better growth and development of crop plants. Apply Nitrofen @ 1-1.5 kg/ha or isoproturon 1 kg/ha in 800-1000 liters of water as pre emergence herbicide application.

14.10 Diseases

Alternaria blight, Downy mildew

14.11 Pests

Mustard saw fly, Mustard aphid, Cabbage butterfly and Bihar hairy caterpillar

14.11.1 Control Spray the crop with one of the following insecticides in the aphid appearance; Imidacloprid 17.8% @ 0.25 ml/l, Thiamethoxam 25 WG @ 0.2 g/l, Dimethoate 30EC @ 1 ml/l of water.

14.12 Harvesting and threshing

Harvest the crop when the pod turns to yellowish-brown. The crop is liable to shattering so harvesting should be done before the pods open in order to avoid losses. Sarson is less liable to shattering as compared to toria and mustard. Moisture content at storage should be 8%.

14.13 Yield

The yield of rapeseed 14-20 q/ha and 20-25 q/ha for mustard.

Lecture 15

15.1 SUNFLOWER

Scientific Name: *Helianthus annuus*

Family: Asteraceae

It is an important oilseed crop contributes 14% of the total oilseed production from nine major oil seed crops. The genus *Helianthus* (Helio=Sun, anthus= flower). Sunflower is known as a “suryajmuki” as it is grown for ornamental purpose. It is the third most important oilseed crop of world after Soybean and Rape seed & Mustard in India. The area and production of sunflower crop significantly increased due to following merits of the crops. Short duration (90-100 days) as it is fit well in multiple and intercropping systems. Wide adaptability: it comes well up in any type of soils. Drought and saline tolerant: suitable for the best component crop in dry land farming. High productivity per unit area per unit time with respect to yield of oil. High seed multiplication ratio (1:80) with low seed rate requirement. It is the best substitute for groundnut crop in contingency crop planning. Due to cross pollination nature, there is a great scope for evolution of high yielding composites and hybrids. Good quality oil with high level of poly unsaturated fatty acids (PUFA) content i.e. linoleic and oleic acids. Linolenic acid is absent. Availability of good quality of hybrid seeds and varieties. It is the best catch crop when the land is left otherwise fallow between two seasons.

15.2 Uses/Economic importance

1. The oil content varies from 48-53% and it is premium oil with pale yellow in color used for cooking and margarine.
2. Sunflower is a rich source of linoleic acid (40-67%) which helps in reducing the cholesterol deposition in the coronary arteries of the heart.
3. Sunflower oil is used as industrial feed stock for manufacturing cosmetics, soaps and pharmaceuticals. Most of 90% fat is good for human.
4. Oil contains high level of alpha tocopherol, a form of vit. E.
5. Oil cake contains 40-50% high quality protein and it is ideally suited for poultry and livestock.
6. The roasted kernels are used as food for human beings.
7. Sunflower is grown as green manure, fodder crop.
8. The best fibre of the stem is source for making rough quality paper.
9. Recently sunflower oil is recognized as an alternative source for fuel.

15.3 Origin

The origin of the sunflower is from Southern USA (Peru) & Mexico

15.4 Area and distribution

It is mainly grown in USSR, USA, Argentina, France, Italy and China. India covers 0.59 million ha of sunflower with productivity of 0.43 million t and yield of 736 kg/ha. Leading states are Karnataka, AP, Telengana, Bihar, Haryana, Maharashtra and UP.

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

- In Northern Telangana Zone
- Maize – Sunflower
- Sorghum – Sunflower
- Sesame –Sunflower
- Mungbean – Sunflower

Scarce rainfall Zone

- Green gram – Sunflower
- Sesame – Sunflower
- Soybean– Sunflower
-

15.6 Varieties

Karnataka: Morden, TANUSAF 7, DRSF 108, DRSF 113

Hybrids: MSFH 8, BSH 1, KBSH 1, Jwalamukhi, Sun-gene 85, PAC 36, PAC 1091, DSH 1, KBSH 41, KBSH 44, Pro-Sun 09

Maharashtra: Morden, TANUSAF 7, Surya, SS 56, LS 11, LSF 8, DRSF 108, TAS 82, DRSF 113

Hybrids: MSFH 8, MSFH 17, KBSH 44, Sun-gene 85, PAC 36, PAC 1091, Pro-Sun 09, MLFSH 47

AP/ Telengana: Morden, TANUSAF 7, DRSF 108, DRSF 113

Hybrids: APSH 11, MSFH 8, KBSH 1, Jwalamukhi, Sun-gene 85, PAC 36, PAC 1091, DSH 1, KBSH 41, KBSH 44, Pro-Sun 09, MLFSH 47, SH 416, DRSH 1

Tamilnadu: Morden, TANUSAF 7, CO 1, CO 2, COSFV 5DRSF 108, TAS 82, DRSF 113

Hybrids: MSFH 8, MSFH 17, KBSH 1, KBS 44, Sun-gene 85, PAC 36, PAC 1091, Pro-Sun 09, DRSH 1

Haryana: Morden, DRSF 108, DRSF 113

Hybrids: DRSH 1, KBSH 1, Jwalamukhi, Sungene 85, PAC 36, PAC 1091, KBSH 44, Pro-Sun 09

Others: Morden, TANUSAF 7, DRSF 108, DRSF 113

Hybrids: KBSH 1, KBSH 44, Sun-gene 85, PAC 36, PAC 1091, Pro-Sun 09, DRSH 1

15.7 Climatic requirement

It is a day neutral plant, Optimum temperature requirement 20-25⁰C. Temperature beyond 38-40⁰C may cause desiccation of pollen and drying of stigma. Rainfall 500-700 mm.

15.8 Soil

Sunflower can be grown in a wide range of soils (Vertisols, Alfisols, Inceptisols and Entisols) with texture varying sandy-loam to deep clay. pH 6.5-8.0, moderately tolerant to alkalinity and salinity, but crop fails below the pH 4.6 on sandy loam soil

15.9 Seed bed

Sunflower requires well prepared deep and friable soil. After primary tillage, the soil should be brought to fine tilth by harrowing and leveling. Fine bed should be prepared. Soil should be thoroughly tilled up to a depth of 20-25 cm.

15.10 Seed rate

The seed requirement for sunflower is 5-7.5 Kg/ha

15.11 Seed dormancy

Freshly harvested seeds have dormancy of 40-50 days. After this period the seeds will be ready for sowing. To overcome dormancy, seeds may be treated with ethryl solution (25ppm), seeds are soaked for 6 hours.

15.12 Seed treatment

The seeds may be treated with Captan/Thiram @ 2.5-3.0 g/ kg of seed. Recent Threat: Necrosis, caused by sucking pests. To manage sucking pest problem at initial stage (up to 30 days), seeds may be treated with Imida-chloroprid @ 5g/kg seed.

15.13 Sowing depth: The depth should not exceed above 3-7 cm.

15.14 Spacing

45cm x 30 cm = 74074 plants/ha

60cm x 30cm = 55555 plants/ha (Thinning should be done, if over-crowded)

15.15 Sowing time

| State | <i>Kharif</i> | <i>Rabi</i> | <i>Summer</i> |
|------------------------|---|--------------------------|--------------------------|
| Karnataka | June-July (R) | Sept-Oct (R) | Dec-Jan (R) |
| | June-July (I) | September (I) | Mid Jan- Feb (I) |
| AP/TG | June-mid July (light soil) | Sept-Nov | Mid Jan-Feb |
| | Late August (heavy soil) | | |
| MS | Last wk June- 1 st wk July | 1 st week Oct | 1 st week Feb |
| TN | June-July (R) | Oct-Nov (I) | Dec-Jan |
| UP & others | July last wk-2 nd wk Oct (R) | | Mid Feb-last March |

15.16 Nutrient management

- The application of inorganic nutrient is N-P₂O₅-K₂O: @ 80-60-40 kg/ha , 50% N+ total of P₂O₅ and K₂O as basal and remaining 50% of N @ 30DAS.
- **S:** Elemental sulphur @ 20-40kg/ha

- **Ca:** 20 kg Gypsum (beneficial to saline soil)
- **B:** foliar spray @ 0.2%
- **Zn:** Foliar spray @0.5%

15.17 Water management

The water requirement for the crop is not more than 25-30 cm

Critical stages

- Seedling (30DAS)
- Bud initiation (bottom stage)
- Flowering
- Bud development

15.18 Harvesting

The harvest should be done by sickle and cutting the head portion. Moisture content of seed during harvesting: 30-40%. Moisture @ storage: 8-10%.

15.19 Yield

The average yield is nearly 20 q/ha

Lecture 16

16.1 SUGARCANE

Scientific name: *Saccharum officinarum*

Family: Poaceae

Genus: *Saccharum* is derived from the Sanskrit word “sarkara - white sugar”. It is an important crop in the Indian sub-continent. Sugar industry is second largest agro-based industry next only to textiles. Sugarcane crop contributes more than 62% of world sugar production. Globally 60 % of white crystal sugar comes from sugarcane and 40 % comes from sugarbeet. India is one of the major producers of sugarcane and sugar in the world. S-cane provides cheapest form of energy giving food [sucrose]. In addition to sugar, 38 value added products are obtained. Juice is used for making of white sugar, brown sugar (khandasari) and jaggery (gur). Is a source as bio-fuel, fibre, fertilizer etc. by products viz, bagasse (power of sugar mills) and molasses [main raw material for alcohol].

16.2 Origin

The *S. officinarum* is native of Indo Myanmar china border and New Guinea.

16.3 Area & Production

Brazil has the largest sugarcane area. Cuba, China, Pakistan, Mexico, S. Africa, Australia, Indonesia, are cane growing countries. Today, India ranks second in the world, after Brazil, in terms of area (4.1 m.ha) and sugarcane production. Among the states, Uttar Pradesh occupies half of the total area followed by Maharashtra. In terms of productivity, Tamil Nadu leads followed by Karnataka and Andhra Pradesh. Bihar, A.P, TN, Karnataka, Gujarat and Punjab are the other cane growing states. Sugarcane in India is grown in two distinct agro-climatic regions-the Tropical (largely comprising Maharashtra, Karnataka, Gujarat and Tamil Nadu) and the Sub-tropical (Uttar Pradesh, Punjab, Haryana and Bihar). There are 3 cultivated species of sugarcane: *Saccharum officinarum*, *S.barberi* and *S.Sinense*, The two wild species: *Saccharum spontaneum*, *Saccharum robustum*.

16.4 Classification

16.4.1 *Saccharum officinarum*

These are thick and juicy canes good for chewing purpose also. contains high sugar content, low fibre. Resistant to smut but are susceptible to red rot. Cultivation limited to tropical areas.

16.4.2 *Saccharum sinense*

Indigenous to north eastern India. They have long and thin stalks, broad leaves, low to medium sucrose content and early matured. Long internodes are present.

16.4.3 *Saccharum barberi*

Indigenous to north eastern India. It is characterised by short and thin stalks, narrow leaves, low to medium sucrose content and early maturity.

16.5 Root system

The fibrous root system is present. the two types of roots, namely sett roots and shoot roots.

The Sett roots is temporary and Shoot roots is permanent root system

16.6 Stalk

Roughly cylindrical and is composed of many distinct nodes and internodes. Above portion of plant which bears leaves and flowers. A small portion of the stalk is below ground which is called rootstock. At each node there is a bud, sometimes known as an eye appearing on opposite sides of the cane. Below the bud there is a raised portion called as leaf scar- attachment between leaf sheath and stalk. Above each node, 2 or 3 translucent dot like structures known as root primordia appear. Root primordia will give rise to sett roots. The inflorescence of sugarcane generally called arrow. Sugarcane flower at the age of 10-12 months.

16.7 Climate

Sugarcane is tropical plant. It will grow in tropics and sub tropics. A growing season which is long and warm with adequate rainfall or irrigation, long hours of bright sunshine and higher relative humidity which permits rapid growth to build up adequate yield. Ripening season of around 2-3 months duration having warm days, clear skies, cool nights and relatively a dry weather without rainfall and higher difference in day (maximum) and night (minimum) temperatures for buildup of sugar are required. Warm summer growing season with adequate rainfall is an ideal climate for sugarcane production.

Temp. > 50°C = arrests its growth.

< 20°C = slows its growth.

- Low temp reduces tillering. Optimum temp = 26-36 °C.

Ideal climate for cultivation of sugarcane in our country such as Maharashtra, parts of Karnataka, A.P.

- Sugar synthesis - 30°C
- Tillering – 30-35 °C
- Root growth – 36 °C (soil)
- Shoot growth - 36°C (soil)

Short day lengths decreases number of tillers / plant. Long day lengths produces more dry matter.

16.8 Rainfall

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

16.9 Sunshine

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

16.10 Soil

Suitable from sandy loam to clay loam. Comes well under drained loamy soils. Grown on light soils under proper irrigation. Heavy soils under proper drainage. Saline, alkaline and acidic, soils are not suitable.

Lecture 17

17.1 Varieties

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

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

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

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

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

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

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

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

17.1.9 Smut disease tolerant varieties: Co8013, Co8014, 81A261, 84A125, 81A48, 83V15, 83V288, 83V96, 89V74, 93V297, 90A272, Co7805, 86A146, 87A397.

17.1.10 for jaggery preparation: Co7706

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

17.2 Cropping systems

17.2.1 North india

Maize – potato-sugarcane

Maize- sugarcane –wheat

Rice – sugarcane – wheat

Cotton- sugarcane – ratoon

17.2.2 South india

Rice- sugarcane- ratoon-wheat

Cotton – sugarcane – ratoon – wheat

Cotton – sugarcane - chickpea

Sugarcane – ratoon- kharif paddy- winter rice

17.3 Intercropping:

17.3.1 Autumn

- Sugarcane + potato
- Sugarcane + wheat
- Sugarcane + lahi (rapseed)
- Sugarcane + lentil

17.3.2 Spring

- Sugarcane + greengram / blackgram

17.4 Field preparation

Field is ploughed 2-4 times with iron plough and pulverization to break the clods. Surface soils are dug to a depth of 20 cm to facilitate drainage and deep root system. Tractor ploughing is a common practice. Sugarcane needs deep tillage, shallow ploughing with local plough limits the development of root system resulting in lodging of cane plants. Sugarcane is mostly grown on alluvium loam soils, one deep ploughing with soil turning plough followed by two cross harrowings. (Northern india) Planking should be done to make the field smooth and clod free.

17.5 Planting season

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

17.6 Duration of Sugar cane crop varies 10-18 months

The Kamsali crops less than 10 months, Eksali crop is nearly 10-12 months and Adsali crop above 12-18 months.

17.7 Seed rate

17.8 Seed selection:

Healthy seed material, free from pests and diseases like red rot, wilt, smut, ratoon stunting should be selected. Top 1/3 to 1/2 portion of a cane being comparatively immature has buds of high viability and is best for sowing. Bottom portion of cane is rich in sugar and takes a long time in germination; this should be used in jaggery making. Ratoon crop is not suitable for seed purpose.

17.9 Seed preparation and treatment:

Before planting, the dry leaves of the cane stalks are removed by hand in order to avoid any possible damage to buds. Thereafter cane is cut into 3 budded setts usually 30-45 cm long. About 35000-40000 setts are needed to plant 1 ha which can be obtained from about 75-80 quintals of cane.

17.10 Sett treatment:

- Setts should be soaked in water if it is drawn from stale and dried canes.
- As a preventive measure against termites and shoot borers setts should be treated with chlorpyrifos, Heptachlor, @1.0 kg/ha.
- Sett rotting: Agallol or Aretan (0.5 %)
- Grassy shoot : Erythromycin
- Leaf scald: Streptomycin (100 ppm)
- Leaf spot: carbendazim (0.1%), COC (0.2%)

Hot air treatment of setts @54 °C – redrot, ratoon stunt, grassy shoot.

17.11 Spacing

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

Lecture 18

18.1 Planting Material

18.1.1 Sett

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

18.1.2 Rayungans

Setts with shoots produced by cutting of the tops of standing Canes.

18.1.3 Seblang

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

18.1.4 Space transplanting [STP]

Nursery beds of 10x5 m, 30 days old seedling for transplanting .600-800 single bud setts are planted in bed @ 2 tons /ha seed material is sufficient against 6-7 tons/ha.Single budded setts from top half of cane is planted vertically.Normal watering & other management aspects are followed

- Less seed rate
- Uniform crop stand
- Reduction in late shoot production
- Low pest and disease attack
- 25 % increase in yield.

18.1.5 Tissue culture technique

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

18.2 Planting methods

18.2.1 Planting in flat beds

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

18.2.2 Ridge and Furrow Method

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

18.2.3 Trench Method or Java method

In some coastal areas as well as in other areas where the crop grows very tall and the strong winds during rainy season cause lodging of cane, trench method is adopted to save the crop from lodging. Trenches at a distance of 75-90 centimeters are dug with the help of ridger or by manual labour. Trenches should be about 20-25 centimeters deep. The setts are planted end to end in trenches.

18.2.4 Rayungan method

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

18.2.5 Distant Planting Method

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

18.2.6 Pit Planting

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

18.2.7 Skip Furrow Planting

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

18.2.8 Sabling or Sprouting Method:

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

18.2.9 Bud transplanting

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

18.3 Manures & fertilizers

18.3.1 Recommended rate of N-P-K fertilizers for AP

- a) Srikakulam, Vizianagaram, Visakhapatnam, Medak: 112+100+100 kg/ha
- b) Nellore, W. Godavari, Krishna, Guntur: 168+100+120 kg/ha
- c) Kurnool, Cuddapah, Anantapur, Chittoor: 224+100+120 kg/ha
- d) Nizamabad: 250+100+120 kg/ha N: P: K = 120-150: 80:60 N1250-350:100:80 kg/ha SI

18.3.2 Nitrogen

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

18.3.3 Phosphorus

“P” requirement is less than N and K. required for adequate tillering. Interacts with N and thus enhance ripening. P deficiency leads to reduced tillering, delays in canopy development, Affects stalk elongation, Less production of secondary and tillering stalks and leaf color appear violet green.

18.3.4 Potassium

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

18.4 Time & Method of application.

The Nitrogen requirement is maximum at tillering, early grand growth period from 1-6 months. Late application of N beyond 120 days, reduces the juice quality and formation of water shoots. Application should be given at 30, 60 and 90 DAP. Phosphorous applied basally in furrow bottom. Potassium application normally done along with N application because of better utilization of N, in the presence of potassium, therefore potassium is applied at 45, 90 DAS. Late application of potassium, at 6 months under drought situations improve sugar recovery. Nitrogen and potassium

fertilizers are given in split doses applied in bands on either side of row. Foliar Nutrition of urea @1- 2.5% & potassium @2.5% under moisture stress is useful to improve yield and quality.

Lecture 19

19.1 Weed management

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

19.2 Water management

Water requirement of cane is high and varies with region. In Tropics, water requirement is 2000-3000 mm, in sub-tropics 1500-2000 mm. Under severe stress the yield loss may go up to 60-70 per cent.

Germination phase = up to 60 DAP

Formative phase = 60- 130 DAP

Maturity = 250-365 DAP.

Water requirement during formative and grand growth phases is more. Light & frequent irrigations gave higher yield, than heavy irrigations at longer intervals. In summer, irrigation interval depends up on soil type and season. Generally shorter interval in winter and in heavy soils whereas longer intervals in summer. In light soils trash mulching has to be done @3t/ha. Irrigation can be provided: 0.75, and 0.50 IW/CPE ratio at tillering, grand growth, maturity.

19.3 Earthing up

Earthing-up is done at 90 - 120 DAP coincides with peak tiller stage. It can be done either manually or by using a bullock- drawn/tractor drawn furrower. Earthing-up @ 120 DAP checks tillering, provides sufficient soil volume for root proliferation, It promotes better soil aeration and provides a sound anchorage or support to the crop and thus preventing lodging and also controls weeds. One more earthing up at 180 DAP may be helpful in preventing lodging.

19.4 Propping

Propping is done to prevent the crop against lodging due to heavy winds and to keep the crop field open for proper aeration. It is done by tying the cane together using dry leaves and bottom green leaves. Trash is twisted to form rope and cane stalks are tied together – trash twist propping.

19.5 Diseases

Red rot, Smut, Wilt, Ratoon stunt and Red stripe.

19.6 Management strategies:

19.6.1 Cultural method:

- Select healthy setts for planting.
- Field should maintain at proper sanitation.
- Ungerminated setts should be removed and fill the gap with new setts which should be treated

before planting.

19.6.2 Mechanical method:

- Treat the setts with hot water at 50°C for about 2 hours this gives 100 per cent control. A temperature higher than this would kill the cane and lower temperature than the specified enables the pathogen to survive.
- Aerated steam therapy eliminates the pathogen from the infected canes. Use of disinfectants to clean seed cutting tools which would reduce the chance of spread of pathogen from the infected to healthy setts.

19.6.3 Chemical method:

- Chemical disinfectants that may be used on cane cutting knives includes, Lysol, Dettol, ethanol, Mirrol and Roccal. Atleast 5 minutes of contact with the cutting surface is needed to assure disinfection.

19.7 Insect pests:

Early shoot borer, root borer, top borer, sugarcane white fly and black bug.

19.8 Management:

19.8.1 ETL: 15% dead heart.

19.8.2 Cultural method:

- Use resistant varieties like CO 312, CO 421, CO 661, CO 917 and CO 853
- Early planting during December – January escapes the early shoot borer incidence.
- Sugarcane intercropped with Daincha recorded the lowest early shoot borer incidence.
- Trash mulching along the ridges to a thickness of 10-15 cm 3 days after planting.
- Ensure adequate moisture to bring down the soil temperature and increase humidity (unfavourable condition for the multiplication of early shoot borer).
- Partial earthing up on 45 days after planting reduces the incidence.

19.8.3 Physical method:

- Remove and destroy dead hearts.
- Install pheromone traps @ 10Nos. /ha for surveillance and monitoring, change the septa/lure once in 30 days.

19.8.4 Biological method:

- Apply granulosis virus 1.5 x 13 5 IBS / ha (750 diseased larvae / ha) along with teepol twice on 35 and 50 DAP.
- Release 125 gravid females of *Sturmiopsis inferens* a tachinid parasite per ac.

19.8.5 Chemical method:

- Apply any one of the following insecticides if the pest crosses ETL.
- Carbaryl +Sevidol 4% G 12.5 kg, Carbofuron 3G 33 kg (Soil application). The granular application should be immediately followed by irrigation.

- Chlorpyrifos 1000 ml a sticker like Teepol (250 ml / 500 l of water) can also be added to make the solution stick on to the surface of the crop and it is preferable to use high volume sprayer to be most effective.

Lecture 20

20.1 Factors affecting ripening:

The different factor which affects ripening are location, low temperature. maximum temperature, varieties ,fertilizers, intercropping, irrigation , lodging, earthing up

20.2 Ripening

Ultimate economic product of sugarcane is not the seed but the sugar stored in stalk. Accumulation of sugars in the stalk begins soon after completion of elongation phase, when glucose produced during photosynthesis is converted to sucrose stored in stalk. As the cane is ripened sheath moisture should drop down from 85 to 72%.

20.3 Maturity stage:

When sucrose exceeds 16%, juice purity increases over 85% - cane is mature. When cane stalk is cut with a knife at above the middle portion, it end looks watery cane is unripe, if it sparkles slightly it is ripening.

20.4 Harvesting:

In NI cane ripens by **early December** but sugar content of **juice rises up to march**. Maturity is recognized by drying of older leaves leaving few top leaves green. If the reading of hand refractometer shows b/w 17-18 the crop is ready for harvest. (Middle portion of cane should be taken for reading). By sweetness of the cane harvest can be done. Stalks are cut at the ground level, dried leaves are stripped off from the cane.

20.5 Constraints: (less sugar recovery and quality)

- Harvested canes should be supplied with in 5-10 days.
- Limited crushing capacity of mills.
- Stocking of canes at mill yard.
- Inordinate delay in transport of harvested cane from field to mills.
- Week end shut down of the factory and unforeseen circumstances.
- Weather parameters like high temp & humidity leads to greater deterioration.

20.6 Products from sugarcane juice

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

20.7 Ratoon management

The number of succeeding cane crops raised from single planting is “Ratoon” it occupies 50-55% of total cane area in India. The crop raised from planting cane setts is “Plant crop”. Plant crop should be

harvested in February to ensure favorable re-growth of ratoon sprout, because sprouting will be poor under low temperatures. Harvesting close to the ground level is most important for good ratooning. Break the ridges so that soil will be loose rather than compact and organic matter will be decomposed. 200 N + 60 P₂O₅ + 60 K₂O are recommended for good ratoon crop. Nitrogen should be applied in 2 splits at ratoon initiation and 60 days after root initiation. Entire dose of P & K should be applied at ratoon initiation.

20.8 Irrigation

- Ratoon crop require more frequent irrigations than plant crop.
- Irrigation at 12-15 days interval in subtropical regions and 8-10 days in tropical areas.
- Earthing up
- Propping
- Weeding
- Plant protection.

20.9 Yield

The harvesting yield come nearly after 11-12 months crop while in north india 400-500 q/ha. 18 months crop of south india is 1000-1200 q/ha.

20.10 JAGGERY MAKING:

- Step 1. Cutting sugar cane from fields
- Step 2. Feeding the grinder to extract juice
- Step 3. Boiling the juice
- Step 4. Adding Ingredients (Na₂CO₃ - reducing agent helps in making jaggery balls)
- Step 5. Tray Feeding
- Step 6. Jaggery output

Lecture 21

21.1 POTATO

Scientific name: *Solanum tuberosum*

Family: Solanaceae

Most important food crop of the world. Poor man's friend. Being cultivated for more than 400 years. Economical food, low cost energy to human diet. Rich source of starch, vitamins especially C and B1. They contain essential amino acids like leucine, tryptophan and isoleucine. Used for production of starch and alcohol.

21.2 Origin

South America, Introduced to India from Europe by Portuguese in 17th century.

21.3 Area and production

Important growing countries are Russia, Poland, USA, China, India, Germany and Spain. In India, the leading states are UP, WB, Bihar and Punjab. Largest producer UP, followed by WB. India, Area: 2.08 mha, Production: 48.01 mt and Yield 23126 kg/ha (2014-15)

Potato Institutes

- Central potato research institute: Shimla
- International Potato Centre: Lima, Peru

True potato seed

The TPS was first evolved through sexual reproduction like tomato, chili, brinjal etc., by Ramanujam in 1957 and subsequently its commercial viability was tested. However, high heterozygosity of seedlings of TPS and uniformity in crop hampered its commercial adoption by farmers. 100 grams of true potato seed, approximately 100,000 to 120,000 seeds. It would take more than 3 tons of 1 ounce seed tubers to start the same number of plants.

21.4 Climate

- Optimum maximum temp for growth & development: 15-25 °C.
- Optimum temp for tuber growth: 17-19 °C.
- Tuber initiation reduced with night temp: > 20 °C.
- High temp affect the tuber growth: >30 °C.

At high temp respiration rate increases and assimilates produced by photosynthesis are consumed rather than stored in the tuber. Under high temperature, plants are elongated, leaves become wrinkled. High humidity along with cloudy days and rains are congenial for spread of fungal diseases. Sunshine along with cooler nights, assures less occurrence of diseases.]

21.5 Soil

Grown on wide range of soils ranging from sandy loam, silt loam, loam and clay soil. Soil should be easily friable, well aerated, deep and well supplied with organic matter. Well drained sandy loam soils rich in humus are most suitable. Well suited to slightly acidic soils, as acidic soil tends to limit scab disease.

- Light soils – easy for harvesting and maintains uniform temperature.
- Alkaline / saline soils are not suitable for potato growing.

21.6. Varieties

Early varieties (70-90 days) : Kufri Pukhraj, Kufri Jawahar, Kufri Ashoka, kufri Laukar

Mid varieties (90-100 days) : Kufri Anand, Kufri Chipsona, Kufri Chipsona 2, Kufri Sultaj, Kufri Swarna, Kufri Lalima, Kufri Bahar, Kufri Jyoti, K. Ckandramukhi

Late varieties (110-130 days) : Kufri Giriraj, Kufri Sinduri.

21.7 Cropping systems

Maize – Potato

Rice – Potato

Soybean – Potato

Cowpea – Maize – Potato

Maize – Potato- Wheat

Maize – Potato- Onions

Jute – Potato – Sesame

21.8 Field preparation

Well pulverized seed bed, for good tubers. Ploughing, 20-25 cm deep with soil turning plough. 2-3 harrowing's or 4-5 ploughing with local plough, 1-2 planking's for leveling, Moisture should be present at the time of sowing. Ridger can be used for commercial large scale planting.

21.9 Mechanization in potato cultivation

- Sub-soiler for deep tillage
- Fertilizer drill for fertilizer application
- Automatic potato planter for planting of tubers
- Potato sprayer for spraying of agro-chemicals
- Multipurpose digger for digging of tubers
- Potato tiller for exposing of leftover tillers
- Grader for grading of tubers
- Treatment machine for treatment of tubers

21.10 Seed and sowing

21.10.1 Selection of seed

Healthy seed tubers, free from pest and diseases. The tubers showing surface disease like wart, scab, brown rot and nematode must be separated out. Seed tubers should be pure, free from varietal mixture. Seed tubers should be certified. Seed tubers must be uniform in size and shape, right stage of sprouting (sprouts are of 1cm long). Seed tubers should not be shriveled. Well sprouted 30-40 g seed tuber (3.5-5.0 cm diameter) is preferable. Whole seed tuber is preferable. It assures less chance of disease infestation. If tubers are cut, then each cut should contain 2-3 prominent eyes. When the tubers are cut and found any diseased tuber, the cutting tool must be disinfected before cutting of another fresh tuber.

21.11 Seed treatment

21.12 Dormancy breaking

To break dormancy tubers are treated with 1% thio-urea (1 kg in 1000 l of water) plus 1 ppm gibberlic acid (1 mg in 1 litre of water) for 1 hour followed by treatment with 3% ethylene and tubers are kept in air tight space for 72 hrs.

21.13 Against fungal disease

Seed tubers may be soaked with 0.2% Mancozeb or Capton solution for 20 minutes to avoid fungal diseases.

Lecture 22

22.1 Planting time

| Region | Season | Planting | Harvesting |
|-----------------------|-------------------------------------|--|---|
| NW Planis | Early Autumn Winter Spring | Mid-September Mid-October October Mid-January | Mid Nov. – Dec. February – March January – March March – April |
| West - Central Plains | Winter | Mid October | February – March |
| NE Plains | Winter | Early November | January – February |
| NE Hills | Summer Autumn | February – Mar September | July – August December |
| NW Hills | Summer Spring | April – June February – Mar | September – Oct July – August |
| Southern Hills | Summer Autumn Spring | Mid April August – Sept January – Feb | August December – Jan May – June |

Source: Text Book of FC Production, Vol.-II, Ed. R. Prasad, ICAR

22.2 Seed rate

The seed required for potato is 30-40 Q/ha.

22.3 Spacing

The row to row distance is 55 and 60 cm (early crop); 45-60cm (main crop) and plant to plant distance is 20and 25 cm (early crop); 15-20 cm (main crop)

22.4 Seed size: The tuber size should 30-40 g.

22.5 Other considerations

Whole tubers should be planted for early crop. This will avoid rotting/drying of tubers. Due to high temp and moisture, more rotting will be there.For main crop, both whole and cut tubers can be planted. Each tuber/ Cut should have 2-3 eyes.

22.6 Methods of planting

22.6.1 Planting on ridges

45-60 cm deep.

22.6.2 Flat method

Shallow furrows, 60 cm apart ridges, made after germination, suitable for light soils.

22.6.3 Planting on flat surface followed by ridges

Shallow furrows 60 cm apart. Planted in furrows after planting small ridges are made.

22.7 Manures and fertilizers

It requires 10-20 t FYM / ha, General Dose N-P₂O₅-K₂O 100-120: 80-120:120 Kg/ha, Soils with good fertility+ loam soils 100-120 kg N /ha, Sandy soils with low organic matter 120-150 kg N /ha, High N delays tuber initiation and maturity of crop. Apply half N and full P₂O₅ and K₂O at the time of sowing, remaining half of N at the time of top dressing (30-35 DAS).

Optimum Fertilizer requirement (kg/ha) is as follows

| Regions | N | P ₂ O ₅ | K ₂ O |
|---------------------|---------|-------------------------------|------------------|
| NW / NE / NC Plains | 110-166 | 25-29 | 34-67 |
| NW hills / NE hills | 85-148 | 66-112 | 64 |
| Southern hills | 120 | 35 | 38 |

22.8 Water management

Drainage is more important. Soil should be kept moist but hardening or too wet conditions of soil should not be allowed. Over-flooding of water on ridges should be avoided. 3-4 irrigations in medium to heavy soil. 8-12 irrigations in sandy soil. Water requirement 30 cm.

22.9 Earthing up

Development of tubers depends up on aeration, moisture availability and soil temp. It should be done when plants attain 15-22 cm height. Earthing is done at the time of top dressing of nitrogenous fertilizers (30-35 DAS). If needed second earthing up done after 2 weeks of first one.

22.9.1 Why earthing is essential

Potato tubers are modified underground stems which use to synthesize anthocyanin and chlorophyll if exposed to sunlight. Therefore, it is essential to cover the tubers fully with soil, because with chlorophyll formation tubers stop accumulation of starch, turn into green and remain smaller. Solanine formation in green tubers result in bitter taste of tubers, and it is harmful if consumed. Solanine is a glyco-alkaloid poison, found in species of the genus *Solanum*.

22.9.2 How harmful solanine

Solanine poisoning is primarily displayed by gastrointestinal and neurological disorders. Symptoms include nausea, diarrhea, vomiting, stomach cramps, burning of the throat, cardiac dysrhythmia, nightmares, headache, dizziness, itching, eczema, thyroid problems, and inflammation and joints pain. In more severe cases, hallucinations, loss of sensation, paralysis, fever, jaundice, hypothermia and death have been reported. Ingestion of solanine in moderate amounts can cause death. One study suggests that doses of 2 to 5 mg/kg of body weight can cause toxic symptoms, and doses of 3 to 6 mg/kg of body weight can be fatal. Symptoms usually occur 8 to 12 hours after ingestion, but may occur as rapidly as 10 minutes after eating high-solanine foods.

22.10 Weed control

Usually manual weeding is done. In case of perennial weeds like motha or doob grass Gramxone @ 2.5 L / 1000 litres of water/ha. As it is contact herbicide it should not be sprayed on crop plants and should spray when crop is 5-10 % germinated. Alachlor (Lasso) – 4l/ha-pre emergence. Metribuzin (Sencor) – annual grasses and broad leaved weeds @ 1kg/ha in 800 L of water.

22.11 Diseases

Late blight, early blight, Black scurf, Wart, Mosaic and Leaf roll

22.12 Pests

Epilachna beetle, Cutworms, Aphids, Leaf hoppers, White grub and Potato tuber moth

22.13 Harvesting

Crop should be harvested when haulms start yellowing and falling on ground. Crop should be harvested about 15 days after cutting the haulms. Optimum moisture should be available. Potato diggers are now available. After digging the tubers to be dried in shade for 2-3 days

22.14 Yield

The yield of potato is 30-40 t/ha

Lecture 23

23.1 FODDER AND FORAGE CROPS

23.1.1 Definition

Fodder refers Coarse grasses such as corn and sorghum harvested with the seed and leaves green or alive, then cured and fed in their entirety as forage or mostly the crops which are harvested and used for stall feeding.

Forage a crop of cultivated plants or plant parts, other than separated grain, produced to be grazed or harvested for use as feed for animals. Forage crops include grasses, legumes, crucifers and other crops cultivated and used in the form of hay, pasture, fodder and silage. Silage (Forage preserved in a succulent condition by partial anaerobic, acid fermentation.)

23.2 TYPE OF FODDER

- Legume Fodder
- Cereal Fodder
- Grass Fodder
- Tree Fodder

23.3 Importance of fodder crops

Forage dry matter consumption should be near 2% of the body weight. At least 19-21% acid detergent fibre should be in the total ration. At least 28-30% neutral detergent fibre should be in the total ration. Provide at least 2 Kg of fibre a day. Rumen PH should be above 6.0. A lower PH could limit fiber digestion and protein synthesis

23.4 Importance of forage crops

Livestock production is an integral part of Indian agriculture. India ranks **first in livestock production** and accounts for 15% of cattle production in the world. States with largest acreage under cultivated fodders are Rajasthan, Gujarat, Haryana, Punjab, U.P., M.P., Maharashtra, and Tamil Nadu. Total area under forage crops in India is 8.3 m.ha which is 4.2 to 4.9% of total cropped area. There is need to improve the fodder acreage up to 8 to 10% of total cropped area to meet the deficit of green fodder for sustained livestock production in India which is considered as an important avocation of rural areas in India.

23.5 Reasons for low productivity of fodder crops

1. Allotment of poor and marginal lands.
2. Poor management practices.
3. Unavailability of seed of fodder crops.
4. Growing less productive forage crops

23.6 Different Institutes for fodder research

- **NDRI**-National dairy research institute, Karnal
- **CAZRI**-Central arid zone research institute, Jodhpur, Rajasthan.
- **IGFRI**-Indian grassland and fodder research institute, Jhansi, U.P.(1962)
- **CSWRI**-Central sheep and wool research institute, Avikanagar, Rajasthan.
- **AICRP NETWORK**-All India coordinated research project on forages was established in the year 1970 with 18 sub centres and main center at Jhansi.
- **NRCAF** – National Research Center for Agro Forestry Jhansi, UP.
- **NDDB** – National Dairy Development Board-Anand, Gujarat.

23.7 BERSEEM

Scientific name: *Trifolium alexandrium*

Family: Fabaceae

Common name: Egyptian clover

23.8 Plant characters

It is considered as king of fodder crops because of its nutritional qualities. It is main fodder for horses, camels and donkeys. Annual bushy shrub and winter growing to a height of 0.9 to 1.0 m with upright and decumbent succulent stem terminating in trifoliate leaves. Seed is pear shaped and yellowish brown color. Crude protein content 18-21% and it is good soil binder.

23.9 Origin and distribution

Berseem is believed to be indigenous to EGYPT. It is introduced in India from Egypt in 1904 and tried at various centers for its performance, with such good results by 1916 it was recognized as a widely adaptable and valuable addition to the forage crops of India. Now it is the prominent fodder legume in irrigated areas of Punjab, Delhi, Rajasthan and Uttar Pradesh.

23.10 Climate and soil

Grows in tropics, subtropics and temperate regions. Temperature range is 25-35°C optimum for seedling growth. 15-20°C optimum for vegetative growth and branching. 35-37°C optimum for

flowering and seed setting. It cannot tolerate frost temperature below 4-5⁰ C. Well drained deep loamy soils rich in lime, P, K with PH 5.5-8.5 are recommended. Do not perform well on sandy soils, water logging and acidic soils. Can tolerate salinity, alkalinity and is thus useful for reclaiming brackish and alkaline lands.

23.11 Land preparation

One MB ploughing followed by 4-5 harrowings are required to make a fine tilth. Fine seed bed is prepared since the seed is small.

23.12 Season

It is a Rabi season crop. Mainly grown in the month of October to November sowings are adopted depending on prevailing temperatures and vacation of kharif crop.

23.13 Varieties

Mescavi: The variety is an introduction from Egypt followed by selection at HAU, Hisar. It is recommended for cultivation in all *berseem* growing regions of India especially Punjab, Haryana and Himachal Pradesh. Plants are shrubby and erect growing up to a height of 45–75 cm, with profuse tillers. Stem is succulent which gives off branches terminating in 2 or 3 leaves. It yields about 65 t/ha green fodder in 4–6 cuttings.

Berseem Ludhiana-1 (BL-1): The variety has been bred through selection by PAU, Ludhiana from Mescavi. It is adapted to Punjab situation. Its first cutting is ready about a week earlier than that of Mescavi. It continues to supply green fodder up to the end of May about 2 weeks late than Mescavi. It yields 80–110 t/ha green fodder.

Jawahar Berseem-1 (JB-1): The variety has been developed at JNKVV, Jabalpur. It is recommended for cultivation in all berseem growing areas of the country especially CZ and NWZ. Its productivity is 70–75 t/ha green fodder and 12–15 t/ha dry fodder.

Wardan: The variety has been evolved through selection by IGFRI, Jhansi in 1981. It provides green fodder yield 70–75 t/ha and dry fodder 12–15 t/ha. This is a diploid variety of Berseem.

BL-10: The variety has been bred through selection from irradiated material of Mescavi by PAU, Ludhiana and released in 1983. Its productivity is 70 t/ha of green fodder.

BL-22: The variety has been developed by PAU, Ludhiana from irradiated material of variety Mescavi followed by pedigree selection. This has been released for temperate and north west zone. The green fodder production is 70 t/ha.

BL-2: The variety has been released in 1989 and developed by PAU by multi-line selection method. Green fodder production is 70 t/ha.

UPB-10: The variety has been developed by developing composite of 5 lines followed by selection at GBPUA&T. It matures in 200–210 days. Green fodder yield is 70–75 t/ha.

Bundel Berseem-2 (JHB-146): The variety has been developed by IGRI, Jhansi. The crop is fairly tolerant to acidic conditions and is fertilizer responsive. The green fodder yield is 90–100 t/ha.

Bundel Berseem-3: The variety is resistant to stem rot and root rot diseases. Green fodder yield of 50–55 t/ha. It is released for NEZ, Bihar Orissa, WB and eastern UP.

JB-5: The variety has been developed by JNKVV, Jabalpur. Suitable in irrigated areas of MP, part of UP, Maharashtra, Gujarat and Chattisgarh. Green fodder yield is 60 t/ha.

Hisar Berseem-1 (HFB-600): The variety has been developed by CCSHAU, Hisar. It yields 75 t/ha green fodder and suitable for late sowing in hill areas of the country.

BL-180: The variety has been developed by PAU, Ludhiana. Suitable for Punjab, Haryana, Uttaranchal, J&K and Himachal Pradesh under irrigated conditions. Average yield is 60–65 t/ha.

BL-180: The variety was developed by PAU, Ludhiana. This variety is suitable under irrigated condition. Average yield is 60–65 t/ha of green fodder.

Lecture 24

24.1 Seeds & sowing

A seed rate of 10- 15 kg/ha in line sowing, 20-30 kg/ha in broadcasting would be sufficient. Bright yellow, plump seeds should be used, discarding all the brown and immature seeds.

24.2 Spacing

Inter row spacing of 25-30 cm is adopted in solid rows. If seed production is taken intra rows spacing of 10 cm is maintained.

24.3 Seed treatment

Seed should be treated with 10% brine (salt) solution to remove the seeds of chicory. Scarified against hard surfaces to soften the seed coat for better germination. Seed is soaked in water for 10-12 hrs or in diluted H₂SO₄ for 2-3 minutes and then rinsed with water 4-5 times. 10% jaggery solution 1.25 kg with 1.25 liters of water is prepared by boiling and cooling to the room temperature. Sprinkle the culture on the seed uniformly and dry under shade. Mix the seed with 10 kg soil and broadcasted or drilled in the field.

24.4 Methods of sowing

Can be sown dry or wet. The land is divided into small plots of convenient size, irrigate the plots to a depth of 5 cm. soak the seed in water overnight and broadcast it in the standing water.

24.5 Manures & fertilizer

Berseem response well to manuring and need about 10 t FYM /ha, 25 – 30 kg N, 80- 100 kg P₂O₅, 30-40 kg K₂O kg /ha. P is applied as SSP and K as MOP, ½ N, total P and K as basal and remaining ½ N should be applied 30 DAS. Micronutrient deficiencies are common with regard to B, Mo, Fe and Zn and has to be corrected. Boron deficiency is very common in coarse textured and leached out soils. Its deficiency causes several pale yellow spots on the leaves which resemble the leaf

hopper damage. Corrected by foliar application of 0.1% borax or soil application of borax @10 kg/ha as basal And Mo as Ammonium molybdate @1- 1.5 kg/ha.

24.6 Irrigation

Water requirement is quite high. Initially irrigation is given at weekly interval later at 10-12 days interval. Crop requires 140cm of water in a year. In places where irrigation water is not sufficient for berseem, oat can be grown as an alternate crop.

24.7 Weeding

Requires thorough weeding in initial stages. *Chicorium intybus* is associated weed of berseem. Remedy is soaking in the 10% brine solution for 10-15 minutes, seeds floating on the water are removed with supplemental hand weeding at 30 DAS. Do not allow the weed to set seed. The seed live in the soil for a long time.

Chemical treatment: 0.75-1.0 kg a.i. /ha pendimethalin, as pre emergence herbicide is recommended.

Incidence of *Cuscuta* is also noticed.

24.8 Harvesting

The first cut can be taken at 55-60 DAS or at 50% flowering stage. Subsequent cuts are obtained at 25-30 days interval. Mescavi types are good for fodder purpose as it gives 5-6 cuttings.

24.9 Yield

The average yield of berseem is 35-55 tonnes/ha/year in / 4-6 cuttings.

24.10 Cropping systems:

Berseem can be substituted with wheat in rice wheat sequence to minimize the incidence of phalaris minor in wheat. Berseem can also be grown as inter crop with Napier Bajra for sustained supply of forage for dairy units. the Maize + rice bean-berseem-sarson.

24.11 LUCERNE

Scientific name: *Medicago sativa*

Family: Fabaceae

Common name: Alfalfa/ snail clover/Chilean clover

24.12 Plant characters and uses:

It is regarded as queen of forage crops. also called as green gold of forage crops. A Perennial bushy herb and growing to height of 1.6 m with upright or decumbent and quadrangular stem. Trifoliate leaves with fast and quick growth habit. Seed is kidney shaped greenish yellow color. Readily accepted by all animals especially horses.

24.12 Origin

It was originally a native of south western Asia.

24.14 Climate and soil

Comes up well in tropics, sub tropics and temperate regions up to 2400m above MSL. Temperature in the Range of 15-25oC-day time, 10-20oC -night time, 20-30oC is required for seed set 15-20oC is optimum for vegetative growth. Well drained deep loamy soils rich in lime N, P, K with pH 5.5-8.5 are optimum. Do not perform well on sandy soils. Can tolerate drought but not water stagnation and high humidity. Remains dormant under conditions of drought and resume the growth in the availability of water in the soil. Acidic soils are not suitable. Root growth is stunted due to less conc of Ca, S and Mg, can thrive on alkaline soils too.

24.15 Land preparation

One MB ploughing followed by 4-5 harrowing to make a fine tilth. Field is made into rectangular sized plots for proper irrigation and better drainage.

Lecture 25

25.1 Varieties

- **Chetak (S-244):** This is a variety developed by IGFRI, Jhansi in 1975. The variety is suitable for cultivation in Punjab, Haryana, Uttar Pradesh and Gujarat. It yields 140–150 t/ha green fodder.
- **Sirsa Type 9:** This variety is released in 1975 by Fodder Research Station, Sirsa. Its yield potential is about 80–85 t/ha of green fodder. Suitable for growing in Punjab, Haryana, Delhi and Uttar Pradesh.
- **Sirsa-8:** This is a variety developed by Fodder Research Station, Sirsa and released in 1975. The variety is suitable for northern India where cold temperature prevails. Its yield potential is about 80–85 t/ha of green fodder.
- **Type-9:** The variety was developed by Fodder Research Station, Sirsa in 1978. This is suitable for northern India where cold temperature prevails. Its yield potential is about 75-80 t/ha of green fodder.
- **Co-1:** The variety was developed by TNAU, Coimbatore. The variety is recommended for cultivation in Tamil Nadu. It has high (20%) protein and the green forage yield is 80–90 t/ha. This is a perennial cultivar which can be maintained successfully for three years.
- **GAUL-1 (Anand-2):** The variety was developed by Gujarat Agricultural University, Banaskantha. The green forage yield is 80–100 t/ha. It is suitable for cultivation in Gujarat, Rajasthan and Madhya Pradesh. Yield is 70–80 t/ha green fodder in 10–12 cuts.
- **GAUL-2 (SS-627):** This is developed by GAU, Banaskantha. It has been recommended for cultivation in whole Gujarat. The plants provide 10 to 12 cuttings in a year with 80–100 t/ha green fodder.
- **LL Composite 5:** The variety was developed by PAU, Ludhiana for cultivation in Punjab. It gives 8 cutting and has a yield potential about 70–75 t/ha fodder and 0.3–0.5 t/ha seed.
- **LL Composite 3:** The variety was developed at PAU, and downy mildew resistant. It provides 38–40 t/ha green fodder.
- **Lucerne no. 9-L:** This variety was developed at PAUniversity, Ludhiana. It grows well for a period of 5–7 years. Its yield potential is about 75 t/ha of green fodder/year.
- **NDRI Selection No.1:** It is developed by NDRI, Karnal. This variety has the capacity of maintaining itself in its pure stands over 5–6 years without getting degenerated. The crop is ready for first cut after 60–70 days of sowing. Its green fodder yield potential is about 100 t/ha.

- **Anand-3:** The variety has been developed by AAU, Anand. It provides 40 t/ha green fodder.
- **RL-88:** The variety was developed by MPKV, Rahuri. This first cut of the crop can be taken in 50–60 days of sowing and thereafter cut can be taken at 25–30 days. The variety yields 75–100 t/ha green fodder in 11 cuts.
- **Anand Lucerne-3 (AL-3):** The variety was developed at AAU, Anand. The plants have profuse tillers (47/plant). It is perennial type with dark green foliage and oblong leaves. The green fodder yield is 97 t/ha.

25.2 Season

It is a Rabi season crop. Sowings are taken up during the months of October & November depending upon the prevailing temperatures.

25.3 Seeds & sowing

A seed rate of 20 kg/ha in line sowing and 30kg/ha in broadcasting.

25.4 Spacing

crop is sown 25-30 cm apart in solid rows x 10 cm

25.5 Seed treatment

Seed should be treated with 10% brine (salt) solution to remove the seeds of chicory. Scarified against hard surfaces to soften the seed coat for better germination. Seed is soaked in water for 10-12 hrs or in diluted H₂SO₄ for 2-3 minutes and then rinsed with water 4-5 times.

25.6 Manures and fertilizer:

Lucerne responds well to manuring which needs about 25 t FYM /ha, 25 – 30 kg N, 120 kg P₂O₅, 40 kg K₂O /ha. P is applied as SSP and K as MOP. Half of N and entire applied and remained P and K as basal which are, ½ N at 30 DAS. Micronutrient deficiencies are common with regard to B, Mo, Fe and Zn to be corrected.

25.7 Weeding:

Require thorough weeding in the initial stages. Cuscuta is a complete stem parasite. Remedy is uproot the plants along with host plants and burnt. Do not allow the weed to set seed. The seed will live in the soil for a long time. Cultivation of Lucerne should be avoided in fields once infested with cuscuta at least for 3 years. Chemical treatment: 0.75-1 kg Pendimethalin as pre emergence herbicide or imazethpyr @ 100 g/ha as early post emergence (10-12 days).

25.8 Irrigation

Water requirement is quite high. Initially at weekly interval then at 10-12 days interval. Crop requires 10-15 irrigations in a year.

25.9 Harvesting & yield

The first cut at 55-60 DAS or at 50% flowering stage. Subsequent cuts at 25-30 days interval. Yielding about **60-80 t/ha/8-10 cuttings**.

Lecture 26

26.1 OATS

Scientific name: *Avena Sativa*

Family: Poaceae

Local name: Oats, jae, jawie, joi etc.

Oat is primarily cultivated for fodder and also for grain. The cultivation practices are similar to wheat. Recently it became very popular due to their health benefits.

26.2 Origin

Oats is Asiatic origin. Asia Minor is believed to be an origin for oats. Three cultivated types are 7 haploid (14 chromosomes), 14 haploid (28 chromosomes) and 21 haploid (42 chromosomes). Common oats (*Avena sativa*) spread in 80% total oat area. *Avena brevis* is short oat grown in South Europe for green fodder. *Avena abyssinica* is Abyssinian oat grown in North Africa. Red oats is grown around Mediterranean region.

26.3 Climate

It is a cool season crop. Do not grow well in hot dry conditions.

26.4 Soil

The crop grows best on well drained, fertile loamy soils. PH range is 5.5-6.5

26.5 Economic importance

Oat bran and whole oats are used for high blood pressure, high cholesterol; diabetes digestion problems including, inflammatory bowel disease (IBD), diarrhea, and constipation. They are also used for preventing heart disease, gallstones, colon cancer, and stomach cancer. Oats is a good cattle feed, human food in the form of good quality grain, oat meal and cookies. Source of low calories, high protein and high fibers. Help in reducing cholesterol. Heart healthy and protect from cancer. Regulates blood sugar levels by improving insulin Sensitivity. Source of good antioxidants. Help in controlling blood pressure. Help in weight loss. Helps in building strong immune system. Source of low calories, high protein and high fibers. Help in reducing cholesterol. Heart healthy and protect from cancer. Regulates blood sugar levels by improving insulin Sensitivity. Source of good antioxidants. Help in controlling blood pressure. Help in weight loss. Helps in building strong immune system.

26.6 Area and distribution

- Oats area and production in the World are about 27m ha and 40m tones, respectively.
- Countries cultivating oats widely are Russian federation, USA, Canada, Poland, China, France and Australia.
- In India, Punjab, Haryana, UP and limited areas in MP, Orissa, Bihar, West Bengal are the Oats growing states.

26.7 Morphology of plant

26.7.1 Stem

- Erect and ascending.
- 40-180cm in length.
- Soft. • Nodes of stem are swollen and internodes are hollow.
- Stem tufted or clustered.
- Oat Stem-inter-node and node

26.7.2 Leaf

- Its leaves are cauline (arise from the upper part of stem).
 - The leaves blade are 14-40 cm long.
 - Oat has veined rough broad leaf.
 - Leaf sheath is smooth and glabrous. Short awns and hairy lemmas
- The compound inflorescence of an oat plant, referred to as a panicle is a continuation of the stem, and terminates in a single spikelet. Development of spikelets involves the formation of several florets, of which primary and secondary kernels develop to maturity

26.7.3 Grain

The grain of oats is called as caryopsis

26.8 Chemical composition of oat

| Chemical constituents | Per-centag Chemical composition of oate at different stages | | |
|-----------------------|---|------------|------------|
| | Young | Milk stage | Ripe stage |
| Crude protein | 14.6 | 6.4 | 9.2 |
| Fibre | 32.8 | 28.7 | 34.8 |
| Nitrogen free extract | 36.4 | 53.2 | 44.7 |
| Ether extract | 2.4 | 2.3 | 1.8 |
| Total ash | 13.9 | 9.3 | 9.3 |
| Calcium | 0.48 | 0.47 | 0.35 |
| Phosphorous | 0.33 | 0.22 | 0.15 |
| Magnesium | 0.22 | 0.22 | 0.13 |
| Sodium | 0.81 | 0.52 | 0.65 |
| Potassium | 4.38 | 2.84 | 2.43 |

26.9 Varieties

- Kent, Algerian, Bunker 10, Coachmen, HFO 114, UPO 50.
- Hybrid varieties :
- Bruncker-10, NP-2, Weston -11, NP-1, Algerian, Bundeljai-822, harita, sabzar.

26.10 Soil and climatic requirement

26.10.1 Climate

It is a cool and moist climate crop. Also, best adapted to cotton belt. Cool weather is important during grain filling for high yield.

26.10.2 Soil:

Wide range of soil with good water holding capacity is more suited for oats cultivation. High N content in soil is not a desirable condition may lead to lodging. It grows best on well drained, fertile loamy soils. PH range is 5.5-6.5

26.11 Cropping system

Sorghum-oat-maize

Maize-oat-maize

Cowpea-oat + mustard-maize + cowpea

Sorghum + cowpea-oat + lucerne

26.12 Cultural methods in oat cultivation

26.12.1 Land preparation

As that of wheat. Seeds and sowing. Fanning the light weight seeds is mandatory. Otherwise, even if those germinate, results weak stem and poor yield. About 25-30% seeds are normally rejected. Seed rate recommended is 100 kg/ha. Best time of sowing for oats is mid-October to mid-November. 15th October is optimum time for fodder production. Method of sowing: Drill sowing is better than broadcasting. Spacing: 20-23cm row spacing for fodder and 23-25cm for grain production is optimum.

Lecture 27

27.1 Manures and fertilizer

12.5 t/ha of FYM is to be applied before last ploughing and to be incorporated before sowing. 80:40:0 kg NPK/ha is the recommended dose of fertilizers. 100% P is to be applied as basal. 60kg N is to be applied as basal, 10kg at first irrigation and 10kg at second irrigation is good for higher yield. 10 kg of N is to be applied after first cutting if sown for fodder cum grain.

27.2 Water management

Oats requires higher water than wheat. 4-5 irrigations provide good yields. Generally, irrigation immediately after each cutting is mandatory. Critical stage for irrigation of oats is tillering stage.

27.3 Weed management

One hand weeding is sufficient in grain, on fodder no weeding required

27.4 Disease

27.4.1 Anthracnose *Colletotrichum graminicola*

Symptoms

Red to brown oval lesions on the leaves; black fungal structures may visible on lesions; crowns become bleached and then turn brown; plants are more susceptible to lodging

Management

Provide plants with adequate levels of fertilizer; rotate crops to improve soil quality; control weeds in field; turn crop debris into soil after harvest to limit release of spores; avoid planting oats in soils with a high pH`

27.4.2 Crown rust *Puccinia coronata*

Symptoms

Chlorotic flecks or brown necrotic spots on leaves or stems; yellow streaks or patches on foliage; brown necrotic streaks on foliage; raised orange pustules may be present on lesions

Management

The most effective method of controlling rusts is to plant resistant varieties of oats; planting oats early allows them to mature before spores reach plants and escape most damage

27.4.3 Loose smut *Ustilago avenae*

Symptoms

Early emergence of heads; dark green or black masses in place of kernels

Management

Use only certified smut-free seed; treat seeds with hot water prior to planting to kill fungi; treat seeds with systemic fungicide (fungi inside seed) fungicide; grow resistant varieties

27.4.4 Powdery mildew *Erysiphe graminis*

Symptoms

Patches of cottony, white-gray growth on upper surface of leaves which turn gray-brown; chlorotic patches develop on leaves opposite fungal growth; fungal fruiting bodies usually become visible as black dots on the mildew

Management

Planting resistant varieties is one of the best ways to protect plants from powdery mildew; other control strategies include: application of appropriate foliar fungicides, if available; removal of crop debris from field after harvest to reduce the level of overwintering fungus; removal of volunteer oat plants which can act as a reservoir for the disease

Insects

27.4.5 Aphids (Bird cherry-oat aphid, Russian wheat aphid, Corn leaf aphid, etc.) *Rhopalosiphum padi*

Symptoms

Yellow or white streaked leaves; flag leaves may be curled up; plants may be stunted and tillers may lie parallel to the ground; plants may turn a purple color in cold weather; insects are small and soft-bodied and may be yellow, green, black or pink in color depending on species; insects secrete a sugary substance called "honeydew" which promotes the growth of sooty mold on the plants

Management

Sturdy plants can be sprayed with a strong jet of water to knock aphids from leaves; insecticides are generally only required to treat aphids if the infestation is very high - plants generally tolerate low and medium level infestation; insecticidal soaps or oils such as neem or canola oil are usually the best method of control; always check the labels of the products for specific usage guidelines prior to use; in commercial plantations aphid numbers are usually kept in check by predators and natural enemies; beneficial insect populations should be assessed before chemical control is considered; if

no beneficial insect populations are present and aphids are damaging then apply appropriate insecticides

27.4.6 Armyworms *Spodoptera praefica*

Symptoms

Entire leaves consumed; notches eaten in leaves; egg clusters of 50-150 eggs may be present on the leaves; egg clusters are covered in a whitish scale which gives the cluster a cottony or fuzzy appearance; young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside

Management

Organic methods of controlling armyworms include biological control by natural enemies which parasitize the larvae and the application of *Bacillus thuringiensis*; there are chemicals available for commercial control but many that are available for the home garden do not provide adequate control of the larvae

27.5 Harvesting

The oat crop mature within 120 days after sowing. For fodder purpose two cuttings are taken at 50-60 day interval. Then oat is left for seed setting. Harvesting for grain is done in early April before plant is dead ripe to avoid shedding of grain.

27.6 Yield

When grown only for grain purpose 16 to 20 qt grain and 25 to 30 qt straw/ha. When grown as fodder the yield is about 200-300 qt fodder and 4 to 5 qts of grain/ha.

Lecture 28

28.1 TOBACCO

Scientific name : *Nicotiana spp.*

Family: Solanaceae

Important cash crop. Grown for its leaves which are used as cured product. Smoked as pipe, cigar, cigarette, beedi or hookah used as snuff or chewed. China ranks 1st in world flue cured tobacco production, followed by Brazil (2nd) and India (3rd). It provides employment potential annually in cultivation, curing, grading, factories and cottage industries. Nicotine sulphate, an industrial product, used as insecticide.

28.2 Origin

Types of tobacco presently being cultivated evolved in Mexico and Central America. In India tobacco was introduced during early part of 17th century by the Portuguese. The word 'tobacco' was originated from "Tobago" (hollow tube).

28.3 Area and distribution

India ranks 2nd in production after China. The principal tobacco growing states in the country are AP, Gujarat, Karnataka, Bihar, Maharashtra, WB and UP. 55 % of total production is from AP and

Gujarat.India (2014-15): Area 0.46 mha, Production 0.84 mt and Productivity 1842 kg/ha
 CTRI: Central Tobacco Research Institute, Rajamundri

28.4 Botanical Classification of Tobacco

The genus *Nicotiana* is one of the five large genera of Solanaceae and is represented by about 68 recognized species.

Description is available for all the 68 species, which are grouped in three sub-groups:

- Sub-genus - *rustica*
- Sub-genus - *tabacum*
- Sub-genus – *petunioide*

28.5 Differences between *Nicotiana rustica* and *Nicotiana tabacum*

| <i>Nicotiana rustica</i> | <i>Nicotiana tabacum</i> |
|---|--|
| Plants are usually taller with a height of 150-250 cm. | Plants are usually bushy with a height of 90-120 cm. |
| Leaves are large and narrow | Leaves are large , broad and ovate in shape. |
| Leaves may be sessile or petiolate | Leaves are petiolate |
| Flower colour is reddish, pinkish or white | Flower colour is dull greenish- yellow. |
| Used for smoking and chewing purpose | Used for hookah, chewing and snuff purpose. |
| Cross between <i>N.slyvestris</i> and <i>N. tomentosa</i> | Cross between <i>N.undulata</i> and <i>N. paniculata</i> |

28.6 Climatic requirements

Tobacco is a tropical crop but can be grown under sub-tropical conditions also. Can germinate at 21⁰ C temperature. 27-32⁰ C for rapid uniform germination 25⁰ C for maturity. Lower temperature increases the growth period and quality is reduced. High temp and hot weather conditions make loss of moisture from the tissues of the plant, leaves become thicker and aroma content is reduced. Drought & low humidity affect the quality and yield adversely. Moderate drought throughout growing period produces thicker leaves, dark colour, does not ferment well and inferior quality in terms of taste and aroma. Water requirement is very high. Rainfall is undesirable at the time of maturity as resins and gums of the leaf gets washed. Suffers severe injury from strong winds and hail. Tobacco plants are very sensitive to flooded/water-logged condition of soil because of deprivation of oxygen in soil essential for the development of a fibrous root system.

28.7 Ideal conditions required for successful production of high quality leaf are:

- 1) A liberal and well-distributed rainfall during active vegetative growth stage
- 2) Long day lengths and
- 3) A high relative humidity of 70-80%.

28.8 Soil

Tobacco is adapted to moderately acidic soils with pH ranging from 5.5-6.5. It will not do well in water logged soils as it is sensitive to water-logging. Tobacco from low lying lands has been found to be very poor in burning quality. Soil should be well drained, good content of K, Phosphoric acid and iron, poor in humus content.

28.8.1 Soil requirement for Special type of tobacco

Heavy and naturally fertile soils: cigar fillers, pipe, hookah and chewing type.

Light sandy and low fertile soils: cigarettes, bidi, cigar wrappers etc.

28.9 Varieties

FCV tobacco: Chatam, Delcrest, Kanakprabha, Dhanadayi, CTRI special, VT 1158, Kanthi, Siri, CM 12, McNair 12, Kachan, Virginia, Gauthami, Bhavya, Jayasri, Hema and Godavari special

Bidi tobacco: GTH 1, Keliu 20m, Anand 3, GTH 2 GT 7, GT 5, PL 5, Anand 119 and Anand 23

Natu tobacco: Viswanath, Natu special, Bhairavi and Prabhat

Cherut tobacco: DR-1, Bhavani special, Sendarapatty special and Lanka special

Wrapper tobacco: Krishna banket A-1, S 5

Chewing tobacco: Vaishali Special, Chama, Podali, Gandak Bahar, Sona, Manasi, Meenakshi, Pusa tobacco 76, DP 401, Vairam, Thangam, Abirami, Prabha, Maragadham and Bhagyalakshmi

Rustica tobacco: DD437, Sonar Motihari, Dharla, GC 1, GCT 2

Cigar Wrapper tobacco: S 5, Krishna

28.10 Field preparation

In all the tobacco growing soils, deep summer ploughing is invariably recommended. This practice is found highly beneficial in minimizing weeds and *Orobanche* menace, reducing insect pest and disease problems and improving water and nutrient conserving capacity of the soil. Pre-planting tillage operation includes one or two ploughings with mould board or disc plough followed by two cross ploughings with cultivator followed by planking for levelling the field. A clean and well pulverized seed bed of good tilth is needed for transplanting of tobacco seedlings.

Lecture 29

29.1 Nursery management

Tobacco seeds are very small and egg-shaped with thick seed-coat. In *N. tabacum* the average weight of the seed is 0.08 to 0.09 mg. In *N. rustica*, the seed is larger and about three times heavier. The emerging seedlings are tiny and delicate and therefore, the seeds are unsuitable for sowing directly in the field. Hence, they are sown in nurseries initially and tended carefully till the seedlings attain a particular size before transplanting in the main field. For successful raising of nurseries, proper location, good preparation and manuring, adequate facilities for watering and timely controlling of pests and diseases are essential.

29.2 Site selection

Generally tobacco nurseries are grown on sandy or sandy loam soils. Raising of nurseries on heavy black soils is hazardous due to poor internal drainage due to clay content, heavy rainfall, and high temperatures.

29.3 Sterilisation

The nursery site should have a good internal as well as surface drainage and should be situated at an elevated place. It is desirable to change the nursery site every year as it would minimize incidence of pests and diseases and also eliminate contamination by other varieties. If it is not possible to change the site, old site can be used after sterilizing by ridding, i.e. by burning any of the slow burning waste materials like, tobacco stalks, paddy husk, sugarcane-trash, etc. For the best results this should be done at the right moisture content, after the final preparation of the seed bed and a few days before sowing.

29.4 Seed bed preparation

The beds of 1.0 m to 1.22 m width facilitate hand weeding and watering with rose cans. The beds can be of any convenient length along the slope but generally not more than 10 m. Mixing of sand at 100 to 200 tonnes/ha in the preparation of the beds, helps in improving the drainage in heavy soils.

29.5 Manures and fertilizers

25 t/ha- FYM Basal application of 50 g of ammonium sulphate, 50 g of potassium sulphate and 300 g of super phosphate and 100 g of dolomite per 10 sq.m. Bed is recommended. After germination of seed, top dressing of ammonium sulphate @ 25 g/10 sq.m. Twice at 4 days interval and thereafter @ 50 g/10 sq.m. Thrice at 4 days interval. Potassium sulphate @ 25 g/10 sq.m. Twice is recommended. After each pulling top dressing with ammonium sulphate @ 100 g/10 sq.m. Is to be applied to boost the growth of remaining seedlings.

29.6 Seed rate

The optimum seed rate is 3-5 kg/ha (0.4 g/sq.M). A seed-rate of 3 kg/ha for N. Tabacum and 6 kg/ha for N. Rustica was found to be optimum.

29.7 Time of sowing:

Sowing for nursery is 2nd fortnight of August. 1st 10 days of nursery period is most critical and if the afternoons are hot, missing even one watering inhibit germination of seed. A week to ten days before planting, seedlings are hardened by withholding water. Such seedlings withstand the shock of transplanting better than normal seedlings. Seedlings of pencil thickness and of 10 to 15 cm length are normally preferred. Normally, the seedlings are ready for planting by the end of 7th week and in the first picking 30 to 40% of the total seedlings are available. The seed bed is top-dressed after each pulling to make the remaining seedlings grow to transplantable size. 5-6 watering are needed on sunny day.

29.8 Transplanting:

In Andhra Pradesh, the normal period of planting is from mid-October till mid-November. (Winter crop) Early plantings are damaged by heavy rains and late plantings suffer from deficiency of soil moisture. In case of summer crop end of the March or 1st week of April.

29.9 Method of planting:

- Dry Planting
- Wet Planting

29.10 Spacing:

- Spacings recommended for various tobacco's in India
- Bidi Tobacco - 90cm X 60cm to 100cm X75 cm
- Natu Tobacco- Irrigated - 90cm X90 cm
- Rainfed - 60cm X60 cm
- Burley Tobacco - 80cm X40 cm
- Lanka Tobacco - 60cm X60 cm

29.11 Manures and fertilizers

In general a normal tobacco crop removes 225 kg N, 17 kg P₂O₅, 365 kg K₂O, 135 kg CaO and 17 kg MgO from 1 ha. Heavy manuring with nitrogen increases yield but quality will be reduced. In chewing, bidi and hookah tobacco better quality heavy manuring of N+ other nutrients. Potash is important element, particularly for smoking tobacco. In heavy soils like vertisols and red clay loams, fertilizers are applied before planting in plant row plough furrow (PRPF) method. In this method, furrows are opened with a plough in the planting row and fertilizers are applied in the furrow and land is levelled with a plank. Later the planting is done on the same line which helps in better utilization of fertilizers. In light soils (sands to loamy sands),

29.12 Nutrient management

Fertilizers are applied in two or three splits by double band placement. Bidi Tobacco : 160-0-0 kg N, P₂O₅ and K₂O / ha. 125-60-40 kg N, P₂O₅ and K₂O / ha. Burley : 125- 5-50 kg N, P₂O₅ and K₂O kg/ ha.

- Irrigated natu: 300-50-100 kg N, P₂O₅ and K₂O / ha.
- Rainfed natu : 60-50-50 kg N, P₂O₅ and K₂O / ha.
- Lanka : 300-50-50 kg N, P₂O₅ and K₂O / ha.
- Cigar : 100-50-100 kg N, P₂O₅ and K₂O / ha.
- Chewing : 120-50-75 kg N, P₂O₅ and K₂O / ha.
- Hookah : 112-50-75 kg N, P₂O₅ and K₂O / ha.

Lecture 30

30.1 Water management

Tobacco cannot tolerate with water logging under any circumstance. FCV tobacco grown in Black cotton soils rarely requires irrigation. However, grown in light soils requires regular irrigations. Irrigation through all furrow system is a general practice, but it consumes more water and requires more labor and leaching losses of nitrogen and potassium are also more. The alternate skip furrow method of irrigation is more economical and checks the wastage of irrigation water, electricity and time. It improves the leaf quality and gives 10-20% higher yield than all furrow irrigation.

| Irrigation time and method | quantity |
|--|----------|
| At the time of planting in plough furrow | 15mm |
| 1st irrigation 15-20th day after planting by surface irrigation, if needed | 24mm |

| | |
|---|------|
| 2nd irrigation 30-35th day after planting as surface irrigation | 24mm |
| 3rd irrigation 40-45th day after planting all furrow irrigation immediately after ridge formation | 48mm |
| 4th irrigation 50-55th day after planting all furrow irrigation | 4mm |
| 5th irrigation 65-70th day after planting by alternate skip furrow method | 24mm |
| 6th irrigation 80-85th day after planting by alternate skip furrow method | 24mm |
| 7th irrigation 95-100th day after planting by alternate skip furrow method | 24mm |
| 8th irrigation 115-120th day after planting by alternate skip furrow method | 24mm |

30.2 Critical stages:

Critical stages for irrigation is knee height to bloom. Scheduling at 50 % DASM is ideal for Tobacco. Quality of water for irrigation to tobacco in respect of chlorine content is paramount important. Limit of is up to 30 ppm and should not exceed 50ppm.

30.3 Weed mangement

The first cultivation usually commences about 10 to 15 days after planting by which time the plants are well established. For each interculture, the soil around the plants is loosened with a hand-weeding tool (khurpi). These operations help in eradication of weeds, mulching the surface soil and promoting rooting at deeper layers by driving out the moisture at the top. Crop is very susceptible to poor aeration and water logging. Orobanche which is a root parasite and is menace to the tobacco crop is kept done by hand pulling. The only way to control this weed is to collect and destroy it before seed formation.

30.4 Topping:

Topping is the process of removal of flower head alone or with few top leaves. Removal of the flower bud (topping) arrests the apical dominance. Done just before or after emergence of the flower head. This stimulates the development of the remaining leaves. It gives a uniform quality product and prevents excessive coarseness in leaves.

30.5 De-suckering:

After the tops have been removed the buds in the axils of the leaves which otherwise remain dormant become active and suckers soon develop in the axils of the leaves. These suckers should be removed by hand before they become large enough to retard the development of the leaves. Removal of these suckers is called desuckering. The main aim of topping and desuckering operations is to divert the energy and nutrients of the plant from flower head to leaves which influence the yield and quality of tobacco.

30.6 Diseases:

Damping off, Black shank, Frog eye leaf spot, Powdery mildew, Anthracnose, Leaf curl and Tobacco mosaic.

Control

- Plant only healthy seed before planting .
- Seed treatment thiram or carbendazim at rate 2.5 g/kg of seed
- Follow three year crop rotation
- plant resistant varieties/tolerant varieties should be taken.

Insects :

Tobacco caterpillar & Looper, Stem borer, Ground beetles and Tobacco capsule borer

Control

Spraying of monocrotophos 36 EC or endosulfan (1 ml in 1 L of water)

30.7 Storage pests:

Cigarette beetle

Control

Uninfested items can be cold- or heat-treated to ensure that any undetected infestations are killed. To prevent reinfestation, clean up spilled flour, mixes, crumbs, etc. and thoroughly vacuum and clean areas where the contaminated items were stored. Store foods in airtight glass, metal or plastic containers.

30.8 Harvesting

The right stage for harvesting the crop is when the leaves are mature ; when the normal green color changes to yellowish green or slightly yellowish and become thick, spotted and sticky to touch.

Lecture 31

31.1 Priming

In tobacco, generally lower leaves mature first followed by upper ones. Therefore, when it is essential for quality that all the leaves at harvest should be correct maturity, harvesting is done by removing few leaves as and when they mature. This method of harvesting is called priming. Harvesting starts from bottom and each time 2 or 3 leaves are harvested at weekly intervals. The entire harvest is completed in about 5-6 primings. This method of harvest is followed in case of cigarette and wrapper tobaccos. After harvesting, the leaves are strung on bamboo sticks at the rate of 100 leaves / stick and loaded in barn for curing.

31.2 Stalk cut method

Hookah, bidi, cigar and chewing tobaccos are harvested by this method. In this method the entire plant is cut to the ground with sickle and left overnight in the field for wilting. The bidi tobacco is ready for harvest when the majority of the top leaves develop red rusty spots known as spangles.

The cigar and cheroot tobaccos are generally harvested when the leaves turn yellowish-green and become brittle which break on folding. Hookah tobacco is harvested when there is indication of yellowish – brown spots of puckering on leaves.

31.3 Curing

Curing is essentially a drying process whereby most of the moisture in the green leaf is removed. However, this process of drying is conducted in such a way as to produce certain well defined and desirable qualities in different types of tobacco. A bad leaf produced on field cannot be improved

by curing; but a good leaf can be spoiled by bad and defective curing. The process of curing has an intimate bearing on the quality of the final produce. During the progress of curing, some important biochemical changes take place. The curing operations followed in India are dependent on several factors, such as tradition, convenience, market value of the crop, consideration of economic production, etc.

31.4 Depending on the type of tobacco, four principal methods of curing can be distinguished, namely,

- i Air-curing,
- ii Fire-curing
- iii Sun-curing.
- iv Flue -curing,

31.4.1 Air curing

The matured leaves are primed and kept around the plant. The primed leaves are tied in to bunch of 8 to 10 leaves and cured on bamboo splinters in curing sheds for 4 to 6 weeks.

Various indigenous tobaccos are subjected to air-curing. Most prominent among them are; wrapper tobacco of West Bengal, lanka tobacco and Burley tobacco grown in Andhra Pradesh. The process is rather slow and takes 6-8 weeks. Generally air-cured tobacco is dark brown in color with lower levels of sugars and rich in nitrogenous constituents. Wrapper tobacco is harvested. The leaves are divided in to groups according to their size and are strung on a sting secured on a bamboo stick. These sticks are taken to barn with closed sides and roof. RH of 70-80 % is maintained by sprinkling of water inside the barn. This process is completed in about 5-6 weeks. Lanka tobacco leaves in AP are strung on ropes in a shade for 8-10 weeks. During this period the leaves turn yellowish- brown. After this process the leaves are placed in a pit for 24 hrs and then transferred to the second pit for 48 hrs and then back to 1st pit for 24-48 hrs. Fermentation of leaf occurs during pit curing. After curing, the leaves attain a dark brown color and fruit smell.

31.4.2 Sun-curing

In India, a number of tobaccos are Sun-cured. In this method construction of costly structures are avoided. The process is relatively quick (2-3 weeks) and there is little interference from weather changes. After initial wilting in the field, Leaves are stung to bamboo poles and sun cured for 15 to 20 days. There are many modifications of Sun-curing.

- a. Curing whole plant on racks: Cigar and chewing tobaccos of Tamil Nadu.
- b. Curing leaves together with pieces of stalk on racks: Natu tobacco in Andhra Pradesh h.
- c. Curing whole plant on the ground: Bidi tobacco of Gujarat, Hookah and chewing tobacco in Bihar.
- d. Curing primed leaves on the ground: Chewing tobacco in Uttar Pradesh and Hookah tobacco in West Bengal.

Lecture 32

32.1 Fire -curing (smoke curing)

Important type of tobacco that is fire-cured is Jaffna tobacco of Ceylon and Tamil Nadu used for chewing purpose. The leaf is harvested by either priming or stalk-cutting each leaf together with a portion of the stem. The leaves are wilted for four hours in the field, tied into bundles and hung of laths in smoke huts. They are then smoked for 12 hours by burning coconut husks, leaf stalks and

palmyrah nuts, stacked for 3 days and again smoked. Alteration of firing and stacking at an interval of few days helps in making the color of leaf uniform. During the smoke treatment, creosotic substances are deposited on leaf surface imparting a peculiar taste. After smoking, the leaves are bulked for 3-4 weeks and treated with salt water/jaggery prior to sale.

32.2 Flue curing

Flue curing tobacco is raised with low level of nitrogen and harvested by priming method. Harvested leaves are strung on sticks which are then stacked in to flue curing barn. Barn is artificially heated. Green leaves should be loaded in upper half of the barn and the lighter ones in the lower half. The three steps in flue curing

1. Yellowing
2. Fixing the color
3. Drying

32.3 Yellowing

During yellowing, leaf is kept at a low temperature and high humidity for about 30-40 hrs till it attains a bright lemon yellow color.

32.4 Fixing colour

After yellowing the temperature is raised gradually and humidity of barn is lowered by opening the ventilators. Great care is required in raising the temperature during this stage. It is raised by not more than 1-2 °F every hour. With rapid rise in temperature, when the leaf is still wet, results in a bluish-black discoloration called Scalding. It takes about 16-24 hrs.

32.5 Drying

It may last from 28-42 hrs. Ventilators are closed and temperature is again gradually raised to 160 °F to dry the veins and midribs of the leaves. This completes the process. Now ventilators are opened to cool down the barn. The leaves are left in barn overnight for absorbing moisture and to come to normal condition for handling and storage.

32.6 Grading

After curing, leaves are graded by sorting leaves into uniform lots according to body, colour and degree of blemish or damage. Most important elements of quality in FCV tobacco are colour, texture, size, blemish, strength, even burning with white ash and agreeable flavour.

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