

CROP PRODUCTION TECHNOLOGY-I, CEREALS, MILLETS AND PULSES (KHARIF CROPS)

COURSE NO. – ASAG2103

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STUDY MATERIAL



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Theory Class course outlines:

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9	17,18& 19	Oilseeds-Groundnut
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Lecture 1

Chapter No.1 RICE (*Oryza sativa*)

Cereals: The crop plants which belong to the family poaceae and are grown for their edible starchy grains/seed called caryopsis (seed coat+pericarp are fused or united) are called as cereals. The word cereals has been derived from 'Ceres', name of a Roman Goddess, means 'Giver of Grains'.

Rice is the most important cereal food crop of the world. It is the staple food for more than half of the world's populations.

C.O: Indoburma region

- Nutritional value: carbohydrate:- 74.8%, protein- 8.4%, but in milled rice- 6-7%, fat-2.6%
- Both amylase and amylopectin (more) are there.
- Lesser the amylase finer the rice quality.
- Rice bran contains 12-14% protein and 20-25% oil.

Classification

- Genus *Oryza* includes 24 species, of which 22 are wild and 2 namely *O. sativa* and *O. glaberrima* are cultivated.
- All the varieties found in Asia, America and Europe belong to *O. sativa* and varieties found in West Africa belong to *O. glaberrima*.
- Based primarily on geographic adaptation and morphological characters of the cultivated *Oryza* rices, the world can be broadly divided into 3 sub species Viz., Indica, Japonica and Javanica

1. Indica :The traditional varieties raised in tropics are called Indicas. These are traditional long duration varieties, photosensitive (season bound), mostly awnless. They are tall, weak stemmed and susceptible to lodging and less responsive to heavy fertilizers

2. Japonica:These are sub tropical and temperate region varieties dwarf in stature with sturdy stems & thus non lodging. Leaves short, thick, narrow, dark green colour. They are awnless to awned varieties, grains are nearly round and fertilizer responsive varieties.

3. Javanica: These are intermediary to Indicas and Japonicas, having morphological resemblance to Indicas. Long panicle with awned grains, low tillering and sensitive to photoperiod (equatorial belt of Indonesia)

Climatic requirement : Of all the weather factors, solar radiation, temperature, RH have greater influence on rice yields.

1. **Solar radiation** : Solar energy is the most important climatic factor in rice cultivation in temperate climates. The plant's most critical period of solar energy requirement is from Panicle Initiation to until about 10 days before maturity which is important for the accumulation of dry matter. The yield of rice during monsoon(kharif) season is lower than that in the dry (summer) season, because of the lower

levels of solar radiation received during the crop's grain filling and ripening stages.

The light compensation = 15000 lux (solar energy/cm) 10.764 feet candles Photosynthesis = Respiration

Light saturation = 45000 lux

2. **Temperature** : It greatly influences the growth and growth pattern of rice plant. Temperature variations are low in tropics and hence needs no significant consideration for the rice cultures in these areas. The critical temperatures for different stages of rice plant are given below. Night temperature of 15-20° C is favourable. Higher mean temperature will reduce the growth duration.
3. **Day Length** : Rice is a **short day** plant and sensitive to photoperiods. Long days can prevent or delay flowering. But photo insensitive varieties enable the farmer in tropics and subtropics to grow rice at any time of the year without great changes in growth duration.
4. **Humidity** : The RH effects in tropics are generally confused with the effects of solar energy and temperature. The average RH before harvest follows a trend opposite to that of the solar radiation values for the same period. Therefore, no importance is attributed to the -ve effect of RH on grain yield of rice.
5. **Wind Velocity** : A gentle wind during the growing period of the rice plant is known to improve the turbulence in the canopy. The air blown around the plants replenishes the Co₂ supply to the plant. Strong winds are detrimental especially at heading. They cause severe lodging and shattering in some rice varieties.

Sl. N	Growth Stage	Cardinal Temperature (°C)		
		Low	High	Optimum
1	Germination	16-19	45	18-40
2	Seedling emergence establishment	12-15	35	25-30
3	Rooting	16	35	25-28
4	Leaf elongation	7-12	45	31
5	Tillering	9-16	33	25-31
6	Panicle initiation	15	-	-
7	Initial flowering	15-20	30	18-28
8	Anthesis	22	35-36	30-33
9	Ripening	12-18	30	20-29

6. **Rainfall** : Variability in the amount and distribution of rainfall is most important factor limiting the yields of rainfed rice, which constitutes about 80% of the rice grown in South and SE Asia. Rainfall variability is more critical for upland rice than for lowland rice. Moisture stress can damage or even kill the plants in an area that receives as much as 200 mm of rainfall in a day and then receives no rainfall for the next 20 days. An evenly distributed rainfall of 100 mm per month is preferable to 200 mm per month that falls in 2 & 3 days. Rice is grown in rainfed conditions with rainfall of 1000-1500 mm/annum, if distributed over 3-3 ½ months. The water requirement of rice is **1200 mm**.

Soil requirement:

Rice is adaptable to all kinds of soils and practically all soil types are found in the world's rice growing areas. The suitability of a soil for rice cultivation depends more on the conditions under which the plants are grown than upon the nature of the soil itself. The semi aquatic nature of the crop necessitates a heavy soil through which the irrigation or rain water will not be easily drained away because the demands of rice are more precise for water than soil conditions. Sandy soils to heavy soils are most preferable to rice crop cultivation.

Rice is able to tolerate a wide range of soil reaction but it may have a preference for acidic soils. The crop has preference to 5.5 to 6.5 P^H. Red soils, black soil and laterite soils are also suitable.

Lecture 2

Growth Stages of Rice Plant

Life cycle of rice plant can be classified into 3 stages – 1. Vegetative stage, 2.Reproductive stage 3.Ripening stage

I. Vegetative stage-It begins with germination and ends with panicle initiation. Unlike the reproductive and maturity phases which are of equal duration for all rice varieties, the vegetative phase varies considerably in length as per the duration of the variety. The vegetative phase can be divided into three stages:

1. **Seedling stage / Nursery stage (Germination to transplanting) (20-25 days):** Seed germinating to time when young plants becomes independent of food reserve of the seed.

2. **Active Vegetative Stage/ (Transplanting to Maximum tillering stage):** This includes sub stages viz.

a) **Recovery stage:** The transplanted seedlings need/require about 9 days to recover from the shock of uprooting during transplanting.

b) **Rooting stage(4-10 DAT):** After recovery of the plant new roots appear. It is known as rooting stage. Once the plants have good established roots, tillers develop rapidly and increase to a maximum number.

c) **Maximum tillering stage(35-42 DAT/60 DAS):** Tiller height and straw weight increases during this stage. The tiller number increases until maximum tiller number is reached, after which some tillers die and tiller number declines and then levels off.

3. **Vegetative lag stage (Maximum tillering to panicle initiation):** this is transition phase between reproductive and vegetative phase.

It includes two sub stages viz

(i) **Effective tillering**

(ii) **Non effective tillering**

During this stage weak tillers begin to die and each strong tiller bears a panicle primordium. The number of these ear bearing (potential productive) tillers come to be fixed which is known as “Effective tillering”. Tillers that develop subsequently do not bear panicles and die ultimately. This is the “non effective tillering”.

II. The Reproductive Phase (Panicle formation to flowering – **35 days**)- The reproductive phase includes the period during which the panicle forms and emerges from the base of the tiller. The reproductive phase begins at panicle initiation, when the panicle begins to develop at the end of the last internode deep inside a protective covering of leaf sheaths. The reproductive phase divided into following stages:

- i. Panicle initiation (PI) stage:
- ii. Internode elongation stage: for early maturity varieties before PI stage
- iii. Booting stage:
- iv. Heading stage
- v. Flowering stage

Booting Stage- With the initiation of panicle primordium, the internode elongates. The sheath of the flag leaf bulges due to the developing panicles within its. This is the “booting stage”. By the time the panicle becomes visible to the naked eye (as a tiny, transparent growth less than 2 mm in length buried within the leaf sheaths near the base of the plant), the booting stage is already underway. During the booting stage, which lasts approximately 15-20 days among all rice varieties, the internodes undergo a

rapid growth sport and quickly lengthen (like a radio aerial extending), causing the culm to shoot up from the base of the plant bearing the developing panicle. During this period of rapid growth the plant's demand for nutrients is high, making the early booting stage a crucial time for fertilization. However, it is sometimes difficult to detect panicle initiation and the earliest onset of booting.

Heading stage- The booting stage is followed by the emergence of the panicle from the protective flag leaf sheath. The heading stage lasts until 90% of the panicles have emerged from their sheaths. Generally it takes about 10 days in most of the varieties.

Flowering stage-The flowering stage begins with the emergence of the first anthers from the 'uppermost spikelets on each panicle. Each individual spikelet flowers for only several hours during the middle of the day on two or three successive days. Flowering begins among the uppermost spikelets and continues for approximately 15 days regardless of variety as the remaining spikelets successively open (the lowermost spikelets flowering last). During flowering, pollen from the anthers is transported by wind and insects to the stigma, which carry it down into the ovaries where fertilization of the ovules occurs. Never apply fertilizer or pesticide during periods of active flowering, as the pollenization process is extremely sensitive and can easily be disrupted by the presence of agro-chemicals.

III. Ripening Stage- The ripening stage begins at fertilization and continues, through grain filling and ripening, approximately **30 days** regardless of variety. Grain filling occurs as nutrients and water are transported from one part of the plant to another; the process is affected by the availability of water and nutrients, and by temperature. Grain filling and ripening can be broken down into four stages:

a) The Milk Stage(7-12 DAF)- The endosperm first begins to form as a milky liquid. Rice at the milk stage is very susceptible to attack by sucking insect pests.

b) The Dough Stage (2-3 wks/ 15-21 days)- The milky liquid begins to solidify into a sticky white paste. During this time bird pests generally begin to be a serious problem.

- Soft dough
- Hard dough

c) The Maturity stage- The grain is mature, or ripe, when the endosperm becomes hard and opaque. While the grains ripen, the leaves of the plant begin to turn yellow as nitrogen is transferred from the leaves to the seed. The full maturity stage is reached when more than 90% of the grains in the panicles have ripened. Mature grains usually undergo a change in color and turn a golden brown, but under wet climatic conditions ripe grains may remain somewhat greenish.

LAND PREPERATION

Preparatory cultivation of main field

Puddling is the reorientation of soil particles at high moisture content due to cultivation, which results in soil particles becoming oriented in respect of each other which causes an increase in bulk density and a large decrease in non-capillary porosity. The main aim of puddling is the mechanical measurement of wet soil in which coarser or larger aggregates are broken down to smaller aggregates reducing the mean particle size. This is an essential operation for wet land rice. Puddling of the soil results in the reduction of macropore space and transforming the upper soil layer into a fine soft mud or puddle.

Mechanical manipulation of the soil at high moisture regime which reduces deep percolation losses is termed as **puddling**.

Objectives of Puddling :

1. To obtain a soft seed bed for the seedlings to establish themselves faster.
2. To minimize leaching losses of N (nutrients) and thereby increase the availability of plant nutrients by achieving a reduced soil condition.
3. Suppression of weeds
4. To mix organic matter with the soil.
5. To create an impermeous sub soil layer for reducing deep percolation & leaching losses.
6. To facilitate easy transplantation.

It can be done by ploughs, tiller or tractor drawn implements depending upon their availability and soil conditions.

Lecture 3

Reactions under water logged situations

Soils under lowland/submerged/waterlogged conditions develop fundamental characteristics different from those of soils under upland conditions.

Waterlogged/flooding causes changes in physical, microbiological & chemical properties of soil because of the physical reactions between the soil and water and also because of the biological and chemical processes set in motion as a result of excess water. These changes have a profound bearing on nutrition and fertilization aspects of rice cultivation.

The most important change in the soil as a result of water logging is the conversion of the root zone of the soil from an aerobic environment to an anaerobic or near anaerobic environment where O₂ is limiting. The flooded or waterlogged soils develops two zones:

- The upper zone : a thin 1 – 10 mm thickness, absorbs O₂ from the water and turns brown in colour (Oxidized zone) and reacts to N like an unflooded upland soil.
- The lower zone: the remaining lower portion of the puddle soil turns to a dark or blue-green colour as iron compounds in the flooded soils lose their O₂. This soil zone is said to be in reduced state.

Sequenstial chemical changes that occur during submergence and puddling in rice

1. Depletion of O₂ molecules and changing in the soil. Oxidation - reduction systems.
2. Chemical reduction of soil, characterization of the oxidized & reduced zones and decrease in redox potential.
3. Increase in p^H of acid soils and a decrease in p^H of sodic & calcareous soils.
4. Reduction of ferric (Fe⁺³) to Ferrous (Fe⁺²) and Mn⁺⁴ to Mn⁺²
5. Reduction of NO₃ and NO₂ to N₂ and N₂ O
6. Increase in the supply of availability of N
7. Increase in the availability of P, Si & Mo
8. Decrease in the concentration of water soluble Zn & Cu
9. Generation of CO₂, Methane(CH₄) & toxic reduction products such as organic acids and H₂S.

(a) Physical changes

- Destroys the structural aggregates in the soil.
- The diffusion/exchange of air between the atmosphere and the puddle soils is impeded.
- Reduced & Oxidised zones develops distinctly

(b) Biological changes

- The rate of decomposition of organic matter is considerably reduced in wet land soils.
- N of organic matter is changed to NH₄ form (stable under water logged conditions) and denitrification losses will take place.

(c) Chemical changes

- Increase in solubility of P
- Reduction of SO₄ to sulphide (Injurious form)

Methods of rice cultivation

1. Dry or semi-dry upland cultivation

a) broadcasting the seed

b) sowing the seed behind the plough or drilling

2. Wet or lowland cultivation

a) transplanting in puddled soil

b) broadcasting sprouted seeds in puddled soils

or

I Direct seeded rice cultivation

- a) Dry seeding: dry seeds are sown in the main field under upland condition after thorough field preparation.
- b) Wet seeding: followed under lowland condition. Pregerminated seeds are sown in puddled soil.

II Transplanted rice cultivation Conditions congenial for direct seeding

Seed rate - 60 to 80 kg/ha Spacing – 20cm*10cm 3 cm depth

I. DIRECT SEEDED RICE CULTIVATION

1. Direct seeding may be very helpful in the dry season when water supply can be very easily regulated.
2. Direct seeding can be adopted profitably in flooded rice where the size of plots for rice cultivation are small and perfectly leveled ensuing good control of irrigation water and soils are light.
3. When the labour shortage is more especially during transplanting period.
4. It saves labour cost and reduces the demand for labour in transplanting season.
5. Facilitates raising of crop in time.
6. The crop matures in 7-10 days earlier than transplanted crop
7. It is recommended where the weed problem is not serious (severe)
8. The expenditure in raising, pulling of seedlings, transporting and transplanting them is saved (limited financial resources).

Advantages

1. Saving of expenditure on seed bed preparation, plant protection & nursery pulling & transplantation. Cost of production is reduced.
2. The crop matures in 7-10 days earlier than transplanted crop.

Disadvantages

1. Higher quantity of seed requirement.
2. Weed control becomes a problem if planting is not adopted.
3. The seed is exposed to bird and rat damage resulting in poor crop stand if broadcasted.
4. There is a greater tendency for the crop to lodge because the base of the plants are not so deeply set in the soil.
5. It is impossible to maintain good stand and in lowlands particularly for monsoon crop, as there is no control over water management.
6. Proper care is needed for adopting optimum seed rate, timely weed control, rational fertilizer application and effective control over water management.

II. TRANSPLANTING

Transplanting of healthy seedlings may be done at 4-5 leaf stage or when they are about 20-25 cm in height @ 2-3 seedlings not deeper than 2-4 cm.

Transplanting can be done in two ways.

1. Random transplanting
2. Straight row planting

Conditions congenial for transplanting

1. Adequate supply of water throughout the crop period
2. Transplanting is done in soft puddle soils.
3. Where weed problem is severe
4. When plant population is not uniform
5. Using community nurseries for timely transplanting.
6. Treatment of seedling for nutrient deficiency and protection against pests & diseases is needed (Root dipping for 'P'slurry, insecticides)

Advantages of transplanting

1. A good leveling of the field is ensured.
2. Weeds are buried at the time of puddling and weed problem is reduced.
3. The plant population becomes more uniform.
4. The availability of most plant nutrients like P, Fe & K is increased and N is converted better.
5. Seedlings transplanted in soft puddle are able to establish themselves faster and start early tillering and growth.
6. Community nurseries facilitate timely transplanting.
7. The treatment of seedlings for nutrient deficiency and for plant protection against pests and diseases is facilitated before transplanting

Disadvantages

1. It involves extra cost on seed bed preparation, plant protection, pulling and transplanting.
2. It needs higher amount of labour at a time when labour is in short supply.
3. It requires more quantity of water.
4. Seedlings are exposed to possible injury during handling.
5. Plants tend to grow more slowly than direct seeding because of recovery time after transplanting.
6. Harvesting is delayed.

Spacing

Kharif : 15 x 15 cm or 15 x 20 cm

Rabi : 15 x 10 cm

With late tillering varieties or overaged seedlings, spacing may be even upto 15 x 10 cm or 20 x 10 cm. However, avoid close planting in endemic areas of BPH incidence.

Lecture 4

FERTILIZER MANAGEMENT

An adequate and balanced supply of plant nutrients is a prerequisite to maximize crop production. The major nutrients required by rice crop are N, P & K.

Throughout the rice growing areas in India, N is the most limiting factor. 'N' is usually deficient where rice is grown because the same conditions of climate which favour rice production cause a rapid turn over and loss of 'N' from the soil.

NITROGEN : Rate of application

For Dwarf and semi dwarf varieties - optimum 'N' rates are 80-100 kg /ha during kharif. 100-120kg/ha during rabi.

Time of application : It depends on the

- (i) Texture of soil
- (ii) Physiological stage of the crop
- (iii) Other management practices-

Efficiency of applied 'N' is higher at active tillering stage than at transplanting and reaches a peak at PI, Beyond PI, the NUE decreases.

Therefore, top dressing is suitable at twice

1. Tillering
2. PI

When more splits are desired (eg: Sandy soils), the period between 3 weeks After tillering until 1 to 2 weeks beyond PI may be beneficial. Basal application is necessary in low fertility soils, early maturing varieties (short duration varieties), poor tillering varieties, widely spaced crops etc.,

Top dressing of N

Application of 'N' at planting and to a lesser extent at tillering, promotes the formation of tillers resulting in more panicles/unit area. Later application increase in panicle weight can be obtained with top dressing around panicle initiation stage. Application at PI stage increases the length of 'Flag leaf' providing a longer photo synthetically active leaf area.

Split application of N have proved to be far better as the efficiency of applied N with split applications is about 30% under transplanted and 59% under direct seeded conditions. Extra yields of 13% in kharif & 23% in rabi have been recorded due to split applications.

Method of application :

Depth of fertilizer placement makes all the differences between efficient use and wastage. The superiority of root zone placement (below 5 cm depth of soil) of N fertilizers to surface applications was well established.

Surface applications resulted in slight losses of gaseous ammonia. NH₃ volatilization losses amounted to 18% of urea N fertilizers are entirely broadcasted.

FUE of root zone placement and that of SCU was nearly double that of split surface application commonly used by farmers.

Placement of N < 5 cm depth of soil increased the yield by 7-10 Q/ha. Incorporation of fertilizers N up to 5 cm depth in the last puddle resulted in higher grain yield than all other methods of application. A plough sole application for N placement in root zone will be very useful. Before top dressing, water is to be drained completely from field for 1 or 2 days.

N is lost through fertilizers as

1. NH_3 volatilisation
2. Leaching
3. Denitrification

For efficient management of N fertilizers in wetland rice – the following measures have to be followed.

1. Right method of application
2. Optimisation of split application of 'N' in relation to growth stages (Right time)
3. Deep placement of N fertilizer in reduced soils.
4. Use of slow release N or controlled release of N fertilizer.
5. Combining the concept of slow release and deep placement of N fertilizers.
6. Furrows of 6 cm deep are opened with a stake in between rows of plants. Fertiliser is placed in the furrows and then the furrow is closed.
7. Irrigation water is let in 24-48 hrs later

PHOSPHORUS: Recovery of P = 26%

Rates of application

Results showed that application of 60 kg P_2O_5 /ha for red soils and 80 kg P_2O_5 /ha for black soils is adequate.

Site specific recommendation on the dose of P_2O_5 to be added through fertilizers can be worked out based on soil test values.

For red soils : $(40 - \text{Soil available } \text{P}_2\text{O}_5) \times 3/2$ For black soils : $(40 - \text{Soil available } \text{P}_2\text{O}_5) \times 2$

Time and Method of application

P fertilizers are best applied basally before seeding in last ploughing by broadcasting and incorporating in the last puddle. Top dressing of P fertilizer in rice is feasible even 15 DAT without reducing grain yield. Placement of P_2O_5 in low land rice proved to be of no advantage.

1. Applying P fertilizers to the nursery was found to be more profitable in certain cases than applying to main field.
2. The recommendation is 2 kg DAP/40 m² of nursery.
3. Dipping rice seedlings in P slurry reduced the quantity of P to be applied to the rice crop in soils which are very deficient in phosphorus.

'P' Slurry-

SSP : Puddled soil : Water

1:3.5:5 should be prepared one hour before use Acid soils - Rock phosphate or bone meal.

POTASSIUM

Potash may become a limiting factor in red & light soils and where leaching losses are likely to be high. Soil application of potash either as MOP or SOP under deficiency conditions will improve yields considerably. About 30-45 kg K_2O /ha is recommended as a maintenance dose to keep available potash in the soil above critical limits for high level production. Potash is applied at the time of last puddling alongwith P as surface application and incorporated.

Time of application

Recent studies have shown that, top dressing of K at maximum tillering and at or before panicle initiation increased rice yields especially in sandy soils poor in potash holding capacity.

ZINC: Zinc is an essential micro nutrient for rice. Its deficiency is associated with soils of high PH

Correction of Zn deficiency In India,

1. Soil application @ 40-50 kg zn SO_4 /ha. (For normal soils once in 3 yrs.)

(For saline soils once in every yr.)

2. By dipping the seedlings in 2% suspension of ZnO is both cheap and convenient.
3. Seed coating is a new development and is at present being used in limited scale in drilled or direct seeded rice production.

IRON : If iron deficiency is noticed spray 1.5% ferrous ammonium sulphate + 75 g citric acid/1lit of water at 4 to 5 days interval till the leaves turn to normal growth.

BIOFERTILIZERS: Some microbes are capable of fixing atmospheric N, while some can increase the availability of N & P.

“Biofertilisers are the microbial inoculants and they which refer to living or latent cells of efficient strains of microorganisms capable of fixing atmospheric N”

Free living organisms : Important amount fixing atmospheric ‘N’ are BGA, Azolla, Azatobacter & Rhizospirillum. Among them, BGA and Azolla can survive only in lowland conditions.

BGA : Several sps of BGA can fix N. The most important species are Anabaena and Nostoc. The amount of N fixed by BGA ranges from 15-45 kg N/ha; standing water of 2.20 cm in the field is a prerequisite for growth of BGA at a temperature of 25-45⁰C and P^H of 7-8 with high organic matter in soils. Bright sunshine increases the growth rate.

Nursery raising : BGA inoculum is applied after transplantation of rice @ 10 kg/ha + 3-4 tons of FYM/ha and 200 kg SSP/ha.

AZOLLA : It is a free floating fresh water fern. *Azolla pinnata* is the most common sps occurring in India. It fixes N due to Anabaena sps of BGA present in the lobes of Azolla leaves. A thick mat of Azolla supplies 30-40 kg N/ha. Unlike BGA, it thrives well at low temperatures. It grows at a temperature of 20-30⁰C and soil PH of 5.5 – 7.0. It grows better during monsoon season with frequent rains and cloudiness.

Azolla is applied to the main field as a green manure crop and as a dual crop. As green manure crop, it is allowed to grow on flooded soils for 2-3 wks before transplanting. Later, water is drained and Azolla is incorporated by ploughing in situ. As a dual crop, 1000-5000 kg/ha of Azolla is applied to the soil one week after transplanting. When a thick mat forms, it is incorporated by trampling. The left over Azolla develops again which is trampled in as a 2nd crop. For better growth of it, 25-50 kg of SSP/ha is applied and standing water of 5-10 cm is maintained continuously in the rice fields.

INM : Plant nutrients can be supplied from different sources viz., organic manures, crop residues, biofertilisers and chemical fertilizers. For better utilization of resources and to produce crops with less expenditure, INM is the best approach. In this, all the possible sources of nutrients are applied based on economic consideration and the balance required for the crop is supplemented with chemical fertilizers. Rice crop residues add 17 kg N/ha. Application of organic matter in any form reduces loss of N fert and increases FUE.

Lecture 5

WATER MANAGEMENT

Although a major part of irrigation water (45%) is directed to rice, yet it covers only 38% of total cultivated area under rice. In other words , 62% of rice area in the country is rainfed. Among cereals, rice has lowest productivity/unit of water (3.7. kg/ha mm). The main reason for growing rice is rainy season and irrigation is provided only during deficit period to make up the water requirement. Percolation losses account for 50-60%

Measures to reduce percolation loses.

1. Thorough puddling
2. Growing rice on clay soils < 5mm/day

3. Scrupulous land leveling
4. Compaction of sub soil
5. Application of tank silt, clay etc.

The water needs of rice are not the same throughout the crop period. It requires small quantities of water in the early stages, gradually increases its water requirement at flowering and early maturing stage and then decreases to the lowest at later stages of crop growth. Hence, scheduling irrigation to meet the crop water demands at different stages is very important. Desirable water depths at different growth stages are as follows where irrigation and drainage facilities are available.

Water requirements of rice at different growth stages

SL.NO.	Growth stage	Depth of submergence (cm)
1	At transplanting	2
2	After transplanting for 3 days (3 DAT)	5
3	3 DAT up to max. tillering	2
4	At max. tillering (in fertile fields)	Nil
5	Max. tillering to PI	2
6	PI to 21 DA flowering	5
7	21 DAF to harvest	Gradual drainage of water

MID SEASON DRAINAGE

Drainage for a day or two during the beginning of maximum tillering stage. This helps to stimulate the vigorous growth of roots and checks the development of non effective tillers. The respiratory function of roots is highest during this stage and introduction of air into the soil by draining the water from field leads to vigorous growth of roots.

Standing Vs flowing irrigation

Irrigation efficiency is usually far higher in stagnant irrigation than in flowing irrigation but the later has the advantage of

1. Leaching down harmful salts
2. controlling soil and water temperatures
3. Reducing labour cost

Irrigation water requirement includes 3 major components of water requirements of rice.

1. Raising seedlings :

It is estimated that 150-200 mm of water is needed for nursery bed preparation and 250-400 mm of water to raise the seedlings.

2. Main field preparation : Amount of water needed to prepare mainfield depends mainly on

- a) Soil type b) its water holding capacity c) the method of land preparation

About 200 mm of water is required for main field preparation of 1 ha

3. **Field irrigation** Crop duration from transplanting to maturity is generally 90-120 days but early maturing varieties, the duration is reduced by 10-20 days. The amount of water required in the field depends upon
- i. Water management practices adopted
 - ii. Soil types
 - iii. Evaporative demand in the season in which the crop is grown

Water requirement from transplanting to maturity roughly comes to 1000 mm with a daily consumption of 6-10 mm/day. The partitioning of water requirement for different growth periods of rice crop is given below :

Table : Total water requirement of rice crop

	Stage of growth	Average water requirement	% of water requirement to total
1	Raising seedlings	40	3.22
2	Land preparation	200	16.12
3	Planting to P1	458	37.00
4	P1 to flowering	417	33.66
5	Flowering to maturity	125	10.00
	Total	1240	100.00

Evaporation – 180-380 mm

Transpiration – 200-500 mm

Percolation – 200-700 mm

According to general experience, the total water requirement is about 1240 mm.

Proper water management will enable

- i) good tillering of the crop
- ii) increase the applied NUE
- iii) minimize weed growth
- iv) reduces the water requirement
- v) increases yield

CRITICAL STAGES

During certain stages of growth, proper management practices gives highest yield and any neglect results in yield loss. During this period, plants are most sensitive to shortage of water. These are known as moisture sensitive periods or critical stages/periods.

Moisture stress due to restricted supply of water during the critical periods will irrevocable reduce the yield and provision of adequate water and fertilizers at other growth stages will not help in recovering the yield lost.

Critical periods of rice are PI, heading and flowering.

Under limited water supply conditions, irrigation is scheduled at moisture sensitive stages and irrigation is skipped at non sensitive stages.

WATER USE EFFICIENCY : (WUE) :

If is defined as the yield of marketable crop produced per unit of water used in ET

$$\text{WUE} = \frac{Y}{\text{ET}}$$

(kg/ha mm of water)

Y = yield

ET = Evapotranspiration

If yield is proportional to ET, WUE has to be a constant but it is not so. Actually ET & Y are influenced independently or differently by crop management and environment. Yield is more influenced by crop management practices ; while ET is mainly dependent on climate and soil moisture. Fertilization and other cultural practices for high crop yield usually increase WUE, because they relatively increase crop yield more than crop water use. Crop production can be increased by judicious irrigation without markedly increasing ET

Methods of irrigation :

Surface method : Flooding, furrow, boarder strip etc., are employed

Lecture 6

WEEDS AND THEIR MANAGEMENT

Weeds reduce yield by 24-48% as they compete with the crop for nutrients, light water and space. Weeds also reduce the quality of crop produce. In transplanted rice it is 15-20%, in Directed seeded rice (puddle soil)30-35% and in upland rice about 50% loss occurs. The potential loss in production of rice in India due to weed infestation is estimated at 15 m tons/annum.

Three types of weeds are found in rice fields.

i) **Grasses** : Monocots, two ranked leaves

Ex : Echinochloa colonum, Echinochloa crussgelli, cynodon sps panicum sps

ii) **Sedges** : Similar to grasses but have 3 ranked and triangular solid stems. They frequently have modified rhizomes adopted for storage and for propagation.

Sedges belong to the family cyperaceae, a large family of monocotyledonous plants distinguished chiefly by having active solid stems and 3 ranked stem leaves.

Ex : Cyperus rotundus, Cyperus iria, Fimbristylis miliaceae

iii) **Broad leaved weeds** : Dicots

Eg : Eclipta alba, Commelina bengalensis, Ammonia baccifera

Crop weed competition : Optimum yield were obtained where the minimum duration of weed control is from 20-30 days.

Weed control - Manual, mechanical & chemical weed control

Rice Nursery :

- (i) Benthocarb (Saturn) @ 2.5-5 lit/ha to be sprayed either on 3rd or 7th DAS will effectively control *Echinochloa* sps without phytotoxicity to rice seedlings.
- (ii) Propanil (Stam F-34) can be sprayed @ 3 ¼ lit/ha at 12-15 days of rice nursery. This herbicide should not follow or precede the application of any fungicide/insecticide.

Transplanted rice :

1,2, 4-Diethyl ester granules @ 20-25 kg/ha (0.8-1kg a.i/ha) applied 3-5 DAT will give better weed control (cost Rs.400-500/ha).

2, 4-Diethyl ester granules at 10 kg/ha + benthocarb at 2.5 lit/ha mixed with sand and applied at 3-5 DAT will be useful when the fields are infested with *Echinochloa* sps (cost Rs.550/ha)

THRESHING : 3 types

1. **Hand threshing of sheaves** : against some hard surface like stone, wooden plank, a bench etc., This is practical when the quantity is small and also for when it is for seed purpose.
2. **Cattle threshing** : It is adopted when large quantity is to be handled. First, a threshing floor is prepared well by removing stubbles, compacting etc., in a circular fashion and the sheaves are spread and trampling under the feet of cattle is made to go round and round.
3. **Tractor threshing** : Now a days, it is widely adopted practice. The sheaves are heaped on the threshing floor in a circular fashion and the tractor goes round and round. In advanced countries, there will be combined thresher and winnowers.

Milling of rice

In the process of milling the aleurone layer and embryo are removed during the polishing of rice grain. All the grain constituents except the carbohydrates are reduced by the process of polishing. There is a loss of Vit B1, thiamine, the deficiency of which causes the disease called 'beri-beri' in those persons who continuously eat 'polished rice'

The loss of nutrients in parboiled rice, during the process of milling & washing with water before cooking, is much less than that in white milled rice. Hand pounding of rice gives a higher recovery as well as more nutritious rice grain.

YIELDS : It varies from season to season, and variety to variety besides several other factors. While the average yields vary from 4-5 tons/ha during kharif. A minimum of 1 more tonne can be expected during rabi for HYV.

Industrial uses: 75-80 lakh tons of paddy straw; supplemental source of raw material for paper industry. 4 mini paper mills produce - 55000 tons paper & straw boards.

Reasons for low yields of rice

1. Widely varying climatic conditions under which rice is grown.
2. Inefficient utilization of applied N
3. Limited scope for optimum water management in heavy rainfall areas.
4. Cloudiness and its ill effects on the photosynthetic activity of rice in monsoon (80% of the season is

cloudy during kharif)

5. Adverse effects of soil salinity or alkalinity (0.024 m.ha in AP & 7 m ha in India)
6. Susceptibility to heavy incidence of pests and diseases which tend to increase under ideal crop conditions.
7. Little scope for rainfed upland rice to achieve its yield potential fully due to short growing season and practically no control over time of transplantation in assured rainfall areas without irrigation facilities.
8. Indiscriminate use of fertilizers.
9. Monoculturing
10. Poor drainage (10 lakh ha. suffer in this zone)

These are the well known reasons which restrict the overall rice production in the country.

Measures to improve the yield

1. Tailoring new varieties which can effectively photosynthesize even under low light intensity .. Eg : IET 9354, Vijaya.
2. effective control of pests and diseases and growing of resistant varieties.
3. Growing varieties tolerant to salinity Eg: MCM-1 ; MCM-2 ; SR-26-B
4. Increasing cropping intensity through early maturing modern rices.
5. Adopting best agronomical practices like adjusting the date of planting in a given locality in such a way that the last 6 weeks of a variety pass through cloud free days.

PARBOILING IN RICE-

A hydrothermal treatment of rice grain immediately followed by drying prior to milling to prepare parboiled grains is called parboiling. It is a hydrothermal process in which the crystalline form of starch is changed in to an amorphous form on account of irreversible swelling and fusion of starch.

Rice grain consists chiefly of an endosperm embodying polygonal starch granules. The air and the moisture fill up the intergranular spaces.

The soaking of a grain either in cold or hot water results in swelling of the starch granules. Soaking in hot water weakens the granule structure by way of breaking the hydrogen bond which consequently provides a larger surface for the absorption of water by the starch granules. The whole process is called gelatinization. Later on, moist heating is done to provide the irreversible swelling or the fusion of the starch granules. Steam is mostly used for moist heating.

Advantages

1. Easily to shell out the parboiled rice.
2. The percentage of broken grains is reduced (Extra strength is provided)
3. More nutritious than raw rice
4. Renders more resistant to insects during storage.
5. Loss of solids in gruel is less than raw rice during cooking.
6. The bran from parboiled rice contains higher oil content. It is better owing to lower content of the free fatty acids.

Disadvantages

1. Due to destroying of natural oxidants, rancidity may develop
2. Parboiled rice takes more time to cook.
3. Common rice consumer may not like the flavour and colour of the par boiled rice.
4. Parboiled rice may contain higher moisture content and some mycotoxins may develop.
5. Drying of parboiled rice to a safe moisture content for storage entails extra expenditure.
6. The milling cost of parboiled rice is higher since the shelled grains are comparatively harder.

Lecture 7

Chapter No.2 MAIZE (*Zea mays*)

Importance:

Maize is one of the important foods, green forage and industrial crops of the world. It is called **queen of the cereals**. The crop plants which belong to the family poaceae. maize has highest yield/ha among the cereal crops. It is now grown in all countries except Antarctica and under a more varied range of climates than any other cereal crops. The National Commission on Agriculture observed that maize can substantially contribute to the additional total food grain production by increasing its present contribution from 6-7% to 10%. Though it is mainly used as a food crop in India by the rural population in the form of bread and gruel, it has vast industrial potentialities as well having many as 50 different uses.

Ex: it can be put to the manufacture of starch, syrup, alcohol, acetic acid, lactic acid, glucose, paper, rayon, plastic, textiles, adhesives, dyes, synthetic rubber, resin, artificial leather, boot polish etc.

Economic importance :-

- Cobs harvested slightly ahead of maturation are grilled and consumed tasty soups and pancakes are cooked out of corn flour. Fermented corn is also common.
- Pop corn, which swells and pops up on rapid heating are much relished snacks consumed all over the world. Corn flour is mostly processed into tortillas in Mexico in Latin America.
- Corn is used in industries in several ways. Grains ground into flour are employed to prepare corn flakes. Corn germ oil is a good cooking medium. Corn starch is raw material in many brews and jams. It is also good for producing alcohol. Some of the non food uses of corn are in preparing starch based adhesive. Proteins are of use in pharmaceuticals textiles, in addition corn germ is used in the soap making industry.

CLASSIFICATION OF MAIZE TYPES :

1. Dent corn (*Zea mays var indentata sturt*)

This is the most common type grown in SA. Dent formation on the top of the kernel having yellow or white colour. The depression or dent in the corn of the seed is the result of rapid drying and shrinkage of the soft starch.

2. Flint corn (*Zea mays var indurata sturt*)

It is widely grown and cultivated in India. Endosperm of kernel is soft and starchy in the centre and completely enclosed by a very hard outer layer. The kernel is rounded on the top. The colour may be white or yellow. Grown in Europe, Asia, central America and South America.

3. Popcorn (*Zea mays var everta sturt*)

It possess exceptional qualities. Size of kernels is small but the endosperm is hard. When they are heated, the pressure build up within the kernel suddenly results in an explosion and the grain is turn out. Grains are used for human consumption and is the basis of popcorn confectionery. Its cultivation is mainly confined to new world.

4. Flour corn (*Zea mays var amylacea sturt*)

It possess a soft endosperm. Kernels are soft and though all coloured corns are grown but white & blue are the most common. They are like fruit kernels in shape. Grown in USA & S. Africa.

5. Sweet corn (*Zea mays var saccharata sturt*)

The sugar and starch makes the major component of the endosperm that results in sweetish taste of the kernels before they attain the maturity and after maturity, the kernels become wrinkled. The cobs are picked up green for canning and table purpose. Mainly grown in North half of the USA.

6. Pod corn : (*Zea mays var tunicata kulesh*)

Each kernel is enclosed in pod. It is a primitive type of corn and hence of no importance.

7. Waxy corn (*Zea mays var ceratina* Kulesh)

The endosperm of the kernel when cut or broken gives a waxy appearance. It produces the starch similar to tapioca starch for making adhesive for articles.

Origin and distribution

Origin of maize plant is still not definitely known, probably because of its wild relatives having become extinct during the long period of cultivation. The wild relative of maize is Teosinte. Geographical origin of maize is said to be somewhere in tropical zone of South America or Mexico, probably in the South western part of the Amazon river basin.

Area and production

Among cereals maize crop occupies 3rd place in the world after wheat and rice. America ranks first in productivity followed by Europe. In these areas maize is used primarily as a source of animal feed. Nearly 54% of the total area is located in South America, Asia and Africa, but they contribute only 33% to the total production of the maize in the world. In these areas, average productivity is low. Maize is consumed primarily as a source of human food. India cultivates 5.4% of the total area and provides 1.7% of the total production of maize in the world.

In India, UP ranks first in area production while the productivity is highest in Karnataka. Punjab ranks fourth position.

Adaptation and climatic requirements

Maize is a tropical plant which prefers warm humid weather. It is grown under extremely divergent climatic conditions in different parts of the world ranging from tropical to temperate regions. Generally, it does not grow satisfactorily in semi arid regions. Since, it is a **short day plant with C₄ type** of photosynthesis, the crop has very efficient utilization of solar radiation. It is very sensitive to excess or deficit soil moisture. It is widely cultivated from 3900m MSL though it varies with latitudes. Therefore, it has adapted mainly in areas having sandy loam soils and sub humid climate. To some extent, the crop is cultivated in areas having semi arid climate provided the soils are deep with heavy texture. The optimum pH range of soil for maize is 6.5- 7.5.

It can be successfully grown where the night temperature does not go below 15^o C. It cannot withstand frost at any stage of growth. Optimum temperatures for germination is 21^oC and for growth is 32^oC. Minimum 9^oC , optimum 32^oC and maximum 46^oC temperature required for growth and development of maize. 600 mm rainfall with even distribution is sufficient for good cultivation.

Soils : Maize can be grown on a variety of soils, but it grows best on well drained soils which are rendered fertile by adequate supply of manures.

Best soils are --- Deep dark silt loams

In semi arid climates -- Deep soils [heavy texture] In sub humid climates --- Sandy loam soils.

Optimum P^H --- 6.5-7.5

Seasons : Kharif season --- with onset of monsoon i.e in June or July and harvested in late September or October.

Crop grown from Oct to January as irrigated one. Sowing maize at about 5 days before onset of monsoon [i.e last week of May to the second week of June] and providing irrigation, results in good plant stand and highest grain yields.

Seed bed preparation [land preparation]:

At least 2-3 shallow tillage operations during summer season are essential in all maize growing areas. Deep ploughing is also helpful to control weeds and for efficient moisture conservation similarly bed and furrow or ridge and furrow systems are suitable in semi arid and sub humid regions. In high rainfall regions ill drainage reduces the yields. Therefore in Dehradun valley the system of ZINGG terracing has been found

suitable.

Seeds and sowing :

Yield of maize remains the same over a wide range of plant populations. On an average 60000-80000 plants/ha is optimum for good yields.

For pure crop --- 20-25 kg seed/ha [60x25 cm or 75 x20 cm]

For intercropping with soybean --- 15 kg/ha [1:2 ratio]

For intercropping with soybean --- 10 kg/ha [1:3 ratio]

For fodder maize --- 40-50 kg/ha

Test weight of variety decides seed rate. High flexibility in crop geometry has been found in case of maize crop. Crop geometry of **45x20 cm** is found to be optimum for most of the areas.

Method of sowing : It is desirable to dibble the maize seed by the side of the ridges at a distance of 1/3 from the top of the ridge. Dibble seed 2-3 cm deep and should not be more than 5 cm. Ridge sowing facilitated irrigation as well as drainage.

Weed management: Timely weed control is important. Proper and timely inter cultivation helps in aeration by loosening the surface soil and assures good yields.

Weeds --- grasses --- *Cynodon dactylon*, *Echinochloa colonum*

Sedges --- *Cyperus iria*, *Cyperus rotundus* *Fimbristylis miliacea*

Brood leaved --- *Celosia argentea* *Commelina bengalensis*, *Convolvulus arvensis*, *Tribulus terrestris*
Solanum nigrum, *Phyllanthus sps*

Maize needs two intercultivations and two handweeding. First inter cultivation is done between rows to break ridges/furrows and earthing up of plant rows. See that intercultivation should not be done too near the plants nor deep to avoid injury to the growing roots. Growing maize by the side of the ridges and earthing up in the early stages reduces injury due to water logging.

Lecture 8

Water management :

Maize is sensitive to both drought and water logging. Proper water management is a must for increasing yields. The most critical period for moisture stress is flowering stage [i.e. **tasselling and silking**]. Upto 40 DAS, the crop is more sensitive to excess moisture and from preflowering to maturity, it is more sensitive to drought.

Maize plant utilizes about half of its seasonal intake of water during the 5 weeks following attainment of its maximum leaf area which is about the tasselling stage. It has been observed that continuous saturation of the top soil even for 4 days has resulted in reduction of yield of 50 q/ha. So it is always advisable to grow the crop on the side of the ridges in areas with poor drainage or heavy rainfall or on black soils. Popcorn is very sensitive to drought. If soil moisture stress occurs during early vegetative stage, then flowering is delayed. Drought at flowering stage, reduces yield and at later stages affect size and popping quality in popcorn.

Furrow method of irrigation is both efficient and convenient for maize crop.

Precautions to be observed with regarding to irrigation and drainage during the life cycle of maize crop:

1. Apply water evenly and uniformly while irrigating the maize crop.
2. Drain out excess water promptly.
3. Open the filed drains at even if to avoid the chances of damage due to excess water or rain.
4. Do not allow the maize crop to wilt due to shortage of moisture.
5. The crop should be irrigated immediately if the leaves roll or wilt during the day and fail to unfold in the following morning. Sometimes leaf wilting may occur in the evenings and the leaves will not recover by the

next morning. This is a sign of extreme moisture stress.

6. Do not allow the crop to wilt at the flowering stage. The soil should be kept moist for proper grain setting and development.

Manures and fertilisers :

At maturity ½ of the dry matter production is accounted for starch in the grain. The percent of N and P in embryo of the seed is highest compared to any other tissue of maize plant. More than ½ of N, accumulates in the grain. There is a continuous uptake of P during the growing season. K accumulates in all the tissues of the plant and it reaches a maximum at about middle of August when sown towards the end of May.

As in other crops, a balanced and integrated nutrient management plays a pivotal role in maize cultivation. The nutrient uptake depends on soil fertility status, variety, crop growth stage, plant density and time of cultural operations.

NITROGEN : The maize crop should have continuous supply of N at all stages of growth till grain formation. N deficiency symptoms are indicated by the yellowing of the tips of lower leaves and the deficiency gradually spreads to mid ribs and finally affects the upper leaves. So N deficiency in maize plants even at an early stage of crop growth will reduce grain yield substantially.

PHOSPHORUS : A higher % of P is needed in early stages than in the later stages. P comprises an important component of maize plant tissues and the developing grains. Thus, if P deficiency exists, it will show up before plants have reached knee-high stage. The contribution of P through fertilizers decreases rapidly though plants take up this element up near maturity.

POTASSIUM : Maize takes up K from knee high to post flowering stage. AP soils are medium to high in available k. So K deficiency in maize is not common. If K deficiency is found, it should be corrected immediately.

ZINC : Majority of maize hybrids growing areas show zn deficiency.

Table no. 2.1 Recommended doses of fertilizers (Kg/ha)

Nutrient	Irrigated	Rainfed
N	120-150	80-100
P	60-75	40-50
K (Based on soil test)	35	35
ZnSo ₄ (once in 3 seasons)	25-50	25-50

Time and method of fertilizer application : In case of rainfed crop, apply all the fertilizers in single dose as basal dressing. Place the fertilizers 10 cm away from seed rows and 5 cm below the seed. In case of other situations, adopt the following method for N in **Table no. 2.2**

Apply 2nd & 3rd splits of N in the after noon when there is no dew. Fert. Should be mixed up in the soil with a hand hoe. Immediately after fert. Application, field has to be irrigated in case of irrigated crop. In case of rainfed crop, the N is to be applied as top dressing, there should be enough moisture in the soil or fertilizers are to be applied after receipt of rain, when the soil is in proper condition.

In case of Zn deficiency, apply 25-50 kg zn so₄/ha as a basal dose to the soil separately and worked in to the soil but not alongwith the basal dressing of phosphatic fertilizers.

In case of ZnSO₄ not applied to soil foliar spray of ZnSO₄ @ 5 kg + 2.5 kg lime/ha. Repeat 2-3 times at weekly intervals till the deficiency symptoms disappear. Basal application of ZnSO₄ is superior and more lasting effect than foliar application.

Symptoms of Zinc deficiency in maize :

Stunted growth with short nodes pale green colour, lower half of leaf having broad ends of bleached tissue while mid rib and leaf margins remain green.

Table no. 2.2

Sl. No.	Type of soil	season	Stage	Method of appln.	Quantity to be apply.
1	Light or sandy	K R S	i) sowing	Drill 10 cm away & 5 cm below the seed rows	¼ N
			ii) knee hight (i.e. 30-35 DAS) (25-30 DAS for popcorn)	Broad cast b/n rows and mix up with soil	½ N
			iii) Pre tasselling i.e. 50-55 DAS (40-45 DAS for popcorn)	-do-	¼ N
2	Heavy or black soil	K S	i) sowing	Drilling	¾ N
			ii) knee hight	Broadcast & mix with Soil	¼ N
		R	i) sowing	Drilling	¼ N
			ii) knee hight	Broadcast and mix with Soil	¾ N

HARVESTING : Hybrids of maize mature within 90-110 days. Test for maturity is that ? the husk cover turns pale brown and the grains are too hard to be pressed in with finger nail. The cobs may be harvested at about 20% grain moisture. The plants may remain green when the cobs are dry and ready for harvest. Therefore do not wait for stalks to dry up for harvesting. This is desirable as such plants can be used as fodder.

SHELLING : Enough time should be given for drying and shelling. Generally, the plants are left in the field for one or 2 days after harvesting. The grains dry up during this period. Remove the husk and cobs are kept in sun for 2-3 days before shelling.

The grains are separated easily from the ears if they are dried thoroughly and grain moisture is reduced to less than 15 %. Shelling can be done either by beating with sticks or by using maize shellers operated by hand or power. After shelling, the grains may be cleaned, dried thoroughly and stored at 10 to 12% grain moisture.

Popcorn ears should be harvested at 30-35% moisture and dried slowly in shade. Quick sun drying results in cracking of grains and poor popping expansion. The ears may be shelled at 12% moisture. The optimum moisture for best popping is 12-14%. Therefore, grain is to be stored at 12% moisture in water proof bags.

YIELD ATTRIBUTES :

1. No. of cobs/plant
2. No. of grains/cob
3. Grain weight/cob
4. Test weight (100 grain weight)

YIELD :

Hybrids : 35-40 Q/ha

Locals : 15-20 Q/ha

High lysine composites :

1. Shakti : 95-100 days ; 10.6% protein ; 3.45% lysine yield 45 q/ha
2. Rattan : 95-100 days ; 10% protein ; 3.46% lysine yield 40-45 q/ha. Grains similar to shakti.
Tolerant to top borer and downy mildew.
3. Protina : Composite with high nutritional quality contains 11% protein; 4% lysine against 2% lysine in normal varieties duration 100-105 days; yield:40-45 q/ha.

Lecture 9

Chapter No. 3 SORGHUM (*Sorghum bicolor*)

It is most important cereal crop in India. It stands second in area (next to rice), but third in production after rice and wheat. It is cultivated primarily as a crop both during kharif and rabi and is one of the main reasons for low average yields (864kg/ha). It is mostly grown in marginal lands which do not suit for wheat and maize. It is one of the major food crops of the world (wheat, rice, maize and jowar). Millions of people in Africa and Asia depend on sorghum as their staple food.

ORIGIN: East and Central Africa (**Ethiopia/ Sudan**) is regarded as the place of origin of sorghum because of the greatest diversity of types grown in that region.

USES OF SORGHUM

1. Jowar is used as human food and animal feed.
2. Jowar is used as fodder for animals.
3. Chopped green stems and foliage are used to prepare hay or silage and also as pasture crop.
4. Sweet sorghum & pop sorghum are perched and consumed by human beings.
5. Jowar flour is used for preparation of roti.
6. It is also used in breweries to prepare alcohol and malting purposes.
7. Jowar cake can also be prepared from fermented dough.
8. Sweet sorghums are used to prepare syrups, biscuit making in bakeries.
9. Left over stubbles are used as a source of fuel.
10. Tribals eat sorghum grains and sweet stems containing 10% sugar.
11. "Vani jowar" is a speciality of south Gujarat which is eaten under green perched conditions.
12. Jowar dhani i.e. pop sorghum is very popular among children.
13. Grain is sometimes fed to cattle, poultry and swines besides being used by human beings.

CYANIDE(HCN) : Sorghum varieties and sudan grass produce toxic quantity of cyanide. The cyanide concentration is highest in seedling stage and declines as the plant grows.

MERIT: The greatest merit with jowar is that it has the capacity to withstand drought due to waxy coating on stems and leaves.

AREA AND DISTRIBUTION: World area is 43.7 million hectares with a production of 62.8 million tones and productivity of 1.3t/ha. While India leads (first) in the world in acreage, USA ranks first in production. The other important jowar growing countries are Pakistan, South America, USSR, Europe, Africa, China, Nigeria, Sudan etc.,

In India, jowar is grown in 10.9 million hectares with a production of 8.0 million tones and the average yield is 0.73t/ha. 1/3 sorghum area is in India.

ADAPTATION

It is a sturdy crop and can withstand varied climatic hazards more than any other crop. It is successfully grown in arid areas of UP, Rajasthan and also in humid regions of W.Bengal and Bihar. It is primarily a tropical warm weather crop. It can withstand wide range of temperatures varying from 15.5 DC to 40.5 DC with rainfall variations of 35-150cm per annum. Although it is a crop of plains, it grows within plateau region of South India up to an elevation of 1000m. Sorghum is a short day plant. Flowering and grain formation starts when day length shortens during winter.

Soils: Sorghum can be grown in heavy black soils to red soils, but comes up well in heavy black soils. The best crops are grown the clay loams. Jowar does not grow well under gravelly and marshy soils. The crop

grows well in neutral pH of 7.0.

Main field preparation: Jawar is a **poor man's crop** which is mostly grown under low input conditions. However, soil management and land preparation are very important items of work for increasing production. The preparation of land for sowing of jowar is not as thorough as for most of the cereals. In black cotton soil areas, if the land is infested with weeds, ploughing followed by harrowing is practiced. Good tilth should be obtained by ploughing with iron plough/country plough for the grain production of jowar. Tractor discing or ploughing is also advisable. Normally, the land is well ploughed, then worked with a cultivator or blade harrow. Cattle manure may be applied 12 t/ha and mixed with soil by ploughing or harrowing. The land is worked with blade harrow 2-3 times, Sometimes gorru without seeding attachment is worked 2-3 times.

In case of irrigated crop, after sowing and covering of the seed, beds are formed with the provision of irrigation channels to irrigate the beds. An irrigation channel is formed for every pair of beds to irrigate the beds situated on either side of the channel. In case of transplanting, beds are formed first, water is let into the beds to soak the land and seedlings are transplanted. For an irrigated crop, the best system is to form ridges and furrows, adopting a spacing of 45cm apart with the provision of irrigation channels at 7.5-10m apart across ridges and furrows to adopt furrow irrigation. At the time of sowing, dibble the seed by the side of the ridge at a distance of 1/3 from the top of the ridge.

Ploughing, harrowing and blinding in jowar is necessary for:

1. Good seed bed
2. Reducing weed population
3. Preventing soil erosion
4. Conserving soil moisture
5. Conserving entire rainfall in dry areas for the USE of jowar crop
6. Providing drainage in wet and humid areas
7. Mixing up organic manures in the seed bed.

YEAR ROUND TILLAGE: To assist the farmers in combating weeds and to enable him to carry out sowing under improved seed bed conditions with this tillage and seeding equipment using bullock power "a year round tillage programme" was developed at CRIDA, Hyderabad.

The year round tillage has several advantages:

1. The primary tillage with country plough in the kharif is done during the non crop season when the farmers are relatively free and at a time when the land and bullocks are in good condition. This operation minimizes carryover of weed population from one crop season to another.
2. The subsequent harrowing operations have the advantage of a thorough weed control. Firm, seed bed and conservation of moisture in the seed zone which in turn enables early planting and good plant stands is so vital for increasing the productivity in dry lands. In an intercropping system, is necessary to till or harrow the field immediately after the harvest of one of the component crops as otherwise weeds take over and the yield of longer duration component is drastically reduced.

GROWTH STAGES OF JOWAR

Development of sorghum crop could be classified into number of ways. A fairly simple classification is based on 3 growth stages (GS₁, GS₂ and GS₃) and are described as follows (Vanderlip and Eastin)

GS₁ (Emergence to PI) : Growth stage 1 is a strictly vegetative period. Relatively little information is available how this stage influences sorghum yields. It is necessary for producing sufficient leaf area and functional root system to support maximum grain development.

GS₂ (PI to Anthesis) : This is very critical stage in the development of crop, since maximum potential seed number is set. Higher seed number has generally is the most important yield component associated with

increasing yield in sorghum.

GS₃ (Anthesis to Maturity): Ultimate yield is the function of both the length of the grain filling period and metabolic or synthetic efficiency. During that period either seed number or potential size (sink) are not limiting.

SEEDS AND SOWING

Sorghum is sown by various methods in different parts of the country. The methods are

1. Broadcasting 2. Drilling 3. Dibbling 4. Transplanting 5. Ratooning

1. BROADCASTING: This method is not much used by farmers because the seed rate required is more and the distribution of the seed is also uneven. Seeds are broadcasted and are covered by working with a country plough. The seed rate varies from 12-18kg/ha. Dry lands require less seed than irrigated lands. This method is usually done in irrigated lands where beds and channels are made and for sowing of fodder sorghum under irrigated farming.

2. DRILLING: It is carried out by locally prepared seed drills, gorru and covered by guntaka or brush harrowing. Seed rate is 8-12kg/ha. Higher seed rate is recommended for light soils and low rainfall areas while lower seed rate is given for black soils. Spacing of 45x15-20cm and at 3-4 cm depth is common in dry soils.

3. DIBBLING: It is a time consuming method and requires more human labour. It is otherwise economical because the seed required is much less i.e. 6kg/ha and gives the equal opportunity to all plants for their growth from the beginning. It is recommended where labour is not a constraint for both kharif and rabi jowar in order to obtain higher grain yield.

Seeds are dropped in plough furrows directly or through bamboo tube attached to plough (akkadi) since the land will be leveled thoroughly and marked with a marker crosswise, keeping a distance of 45x15cm. The seed is covered by the succeeding furrow. This method is adopted usually in dry lands, where the moisture content of the soil is low. In case of irrigated crop, 2 or 3 seeds are dibbled by the side of the ridge adopting 12-15cm spacing in the row, where ridge and furrow method is adopted. Depth of sowing will be around 2.5 to 5cm by adopting population of 1.8 to 2 lakhs/ha. Thinning is to be done at 15 to 20 DAS leaving one seedling per hill. Fill up the gaps with the pulled seedlings. This method is usually practiced in sorghum research centres.

4. TRANSPLANTING: In areas with sufficient rainfall, transplanting of jowar seedlings is done. This practice is prevalent in the districts of Srikakulam, Vizag, E&W Godavari districts with regard to cultivation of KONDA JONNA during July-Aug. When the soil gets sufficiently moist, seedlings of jowar obtained from a nursery after topping the leaves are dropped in the plough furrow. The root portion of the seedlings is covered when the next furrow is opened. As an irrigated crop, the beds of the field are irrigated and seedlings are planted. Even the hybrids can be transplanted. A light irrigation before or soon after planting helps for better establishment. The transplanting method is mostly used for hybrid sorghum. In Tamilnadu and in adjoining areas of Tirupathi, the seed growers follow the transplanting method of sowing. This method is developed by them for obtaining perfect synchronisation of male and female lines of sorghum hybrid CSH-5. The female lines are dibbled by hand or drilled directly in the fields. The male lines are sown in the seed bed. The 2 week seedlings of male lines are then transplanted in the field in the ratio of 4 female lines to 2 male lines. Due to transplanting of male lines, the flowering in the male lines would be delayed by about a week. Due to this method, the farmers in South India are able to organize a good hybrid sorghum seed production programme than North Indian farmers.

5. RATOON CROP: The cultivation of an additional crop from the regrowth of stubbles of previous main crop after its harvest, there by avoiding reseedling or replanting such as sugarcane, sorghum, rice, fodder grasses etc. Hybrids of sorghum can be ratooned with good success. They give extra 11 quintals yields to the

main crop if they are properly managed. Out of all CSH-1 is the best for ratooning and the local varieties are not at all fit for ratooning. This is only possible under irrigated conditions.

STEPS: 1. The main crop has to be harvested while the stem is green, leaving 4" to 6" stubble above ground level.

2. The 2nd day after harvesting, an irrigation has to be given to induce sprouting from the nodes.
3. Fertilizers @ 60kgN/ ha has to be applied at 2 splits. 1st split at the basal stage and the 2nd split of N at 30 days after from date of ratooning.
4. From each stubble, a number of sprouts come up. The weak sprouts have to be thinned out leaving 2 or 3 good healthy sprouts in each stubble
5. Maintain sufficient moisture from boot leaf to grain hardening stage.
6. The ear head size though small in ratoon crop gives equal yield to main crop as it put forths 2 or 3 sprouts.
7. Ratoon comes to harvest in 80-85 days.
8. Plant protection measures have to be taken up in time against pests and diseases as in planted crop.
9. For a ratoon crop of jowar, all the plants in the field have to be harvested at one time.
10. Ratooning reduces expenditure on land preparation, sowing, fertylisers and gives more net income when it is managed well.

Spacing for sorghum: 45x12-15cm

Seed treatment: For control of grain smut disease - treat the seed with sulphur @ 5g/kg seed.

OR With organo mercurial compounds or carbomates @ 2.5g/kg seed. For shoot fly-carbofuran 50 WP@ 100g/kg seed.

Lecture 10

MANURES AND FERTILISERS : Both N & P are essential for stepping up grain yields of jowar. The effect of P in increasing grain yield is more pronounced when it is applied in combination with N. Application of N consistently increases uptake of P at all stages of growth. N uptake is also significantly increased at high levels of P application even at 60 days growth stage. Response to N is better in hybrids than in local improved varieties. Response of jowar to K is infrequent. K need not to be applied to jowar except in areas known to be deficient regarding potash. For rainfed varieties, in many cases 25kg N+ 25 kg P₂O₅/ha gave higher yields compared to 50kg N/ha under dry land conditions. Under irrigated conditions the doses of N & P are 40 kg/ha each.

TIME AND METHOD OF APPLICATION OF FERTILISERS : When fertilizers are applied in direct contact with seeds, injury to germination frequently occurs. Drill the fertilizers into the soil before the sowing of seed at 5cm below the seed level. Basal application gives better response when drilled into the soil.
HEAVY SOIL: All N & P₂O₅ could be applied basally or drilled into the soil at sowing 2" away and 2" below the seed.

LIGHT SOILS: N should be given in 2 equal splits i.e. half as basal and other half at 30-35 DAS i.e at knee high stage.

General dose for HYV's is 80-40-20 kg NPK/ha

POINTS TO BE CONSIDERED FOR EFFICIENT FERTILISER MANAGEMENT

1. Jowar crop removes large quantity of nutrients from soil.

2. Growth and nutrient uptake will be more rapid after 40 days from sowing. Adequate supply of nutrients and water are necessary to provide maximum growth.
3. Jowar ear heads may not exert out completely from the flag leaf without adequate nutrients and water.
4. Final grain yield depends upon the rate of dry matter accumulation in the grain. NPK are necessary for dry matter accumulation. Nutrients at all stages of development of jowar crop are required for obtaining maximum yield.
5. Use of fertilizers after getting the soil properly tested.

WATER MANAGEMENT: Though jowar is drought resistant, it responds well to irrigation. It is primarily a rainfed crop. It has an extensive and deep fibrous root system. It is observed that on an average, about 6-9 irrigations, each of 5-6 cm depth are necessary depending on climate. Total water requirement is about 500-600mm.

CRITICAL STAGES FOR IRRIGATION: Irrigation is needed at 5 stages of the crop i.e.

1. Germination (at the time of sowing)
2. Knee high stage (30-35 DAS)
3. Flag leaf stage (50-55 DAS)
4. Flowering (70-75 DAS)
5. Grain formation stage (100-105 DAS)

The peak water needs of jowar crop is at booting to seed setting stage.

TIME OF IRRIGATION: The optimum time for irrigating jowar is when the soil moisture (ASM) is depleted to the extent of 50-60% in the effective root zone. It was observed that irrigating the crop when the ASM falls to 50% in the root zone of 60 cm has given the highest yield of grain.

Irrigations to maintain a high moisture content during the seedling stage of the crop have been found to be detrimental to the growth of jowar due to lowering of soil temperature below the optimum and leaching of plant nutrients from the root zone. Irrigation at 45th day even for rainfed crops which coincides with boot leaf ensures good yields.

Peak water requirements are at boot to flowering and early grain development stages i.e 25th , 45th and 55th DAS. These days correspond to PI, boot leaf and flowering respectively. For irrigated crop, irrigation once in 7-10 days for light soils and once in 15-20 days for heavy soils may be necessary. About 50% of jowar root is within 50 cm depth of soil though roots may go as deep as 150 cm. A pre-sowing irrigation to bring 120 cm depth of soil to field capacity is essential. An irrigation at 15 days after emergence in shallow soils is important. The irrigation may be given to bring 90 cm of the soil to field capacity.

POINTS TO BE CONSIDERED FOR BETTER WATER MANAGEMENT IN JOWAR

1. Deep tillage and other moisture conservation practices to increase infiltration and soil moisture storage.
2. To provide drainage in black cotton soils during periods of excessive rainfall as jowar crop cannot tolerate water logging conditions.
3. Water harvesting during periods of excessive rainfall to make use of all available water for improving and stabilizing crop production.
4. Following improved irrigation techniques and timing to utilize a limited supply of tank or well water most effectively.
5. Adjusting of planting dates and cropping systems to optimize efficiency of water use.
6. Use of fertilizers and other improved production practices to increase WUE.
7. Severe moisture stress after flowering in kharif jowar can result in "blasting" and poor head filling. Providing only one irrigation at this stage can boost yield.

8. Final yields depends on the rate of dry matter accumulation in the grain and the length of time it accumulates. So, all the factors related to improve dry matter accumulation should be efficiently managed.

Important weeds associated with sorghum:

Grasses : *Cenchrus sps, Digitalis sanguinalis, Echinochloa crussgalli, Eleusine indica*

Sedges : *Cyperus rotundus*

Broad leaved weeds : *Amaranthus viridis, Celosia argentina, Commelina bengalensis, Striga lutea*

Weed management: Mechanical – intercultivation

Rainfed crop: Inter cultivation is done in between rows with small implements known as danthi i.e., small blade harrow - i)to remove weeds ii)to stir the top soil and iii)to give slight earthing up to jowar plants. A light country plough is also used for this purpose and the interspaces are ploughed. Interculturing commences when the crop is about 15-20 DA5 and it is repeated at 10 days interval.

Irrigated crop: A hand weeding is done within 20 DAS. A light plough is worked in between rows to break the ridge and earth up the rows of jowar plants when the crop is 30-38 cm in height.

Chemical: (a) A pre emergence application of Atrazine or Propazine @ 0.25 - 0.50 kg a. i./ha in 900 lit water for effective control .This is followed by a late weeding which is the best and safest.

(b) A post emergence application of 2 lit of MSMA /ha in 700 lit water can be used to control nut grass effectively. During the application, avoid as far as possible spraying on the crop (MSMA=Monosodium methyl arsenate)

(c) 2,4-D @ 0.75-1.0 kg a.i./ha as post emergence 4-5 days after sowing for broad leaved weeds.

One or two inter cultivations in sorghum may provided adequately effective control of weeds.

Striga

Witch weed (striga sps), a root parasite which falls in the group of higher parasitic plants, comprises of major threat to sorghum production. The common species of striga are 1.*Striga asiatica* 2.*Striga lutea* 3.*Striga densiflora* 4.*Striga euphrasiodes* 5. *Striga hermonthica*.

Striga lutea , an erect herb grows to a height of 10-30 cm. It is the most wide spread species of striga causing severe crop losses and occurs through out India.

Striga robs the host sorghum plant of food and hormones through the roots attached to the sorghum roots. Growth of sorghum consequently remains stunted and the plant vigour is adversely affected. The total effect is drastic reduction in sorghum yield. This parasite which grows on the root of jowar plant, depleting it of its nourishment and there by arresting the growth and reducing the yield.

Striga can be controlled by systematic removal before it flowers. Spraying with chemical weed killer, methaxone or 2,4-D @ 0.2% solution can control striga. Some other measures to control striga are 1.Deep ploughing 2.Double the recommended dose of N 3. Growing resistant varieties like SPV-462, N-13 etc., 4.Growing catch crops and trap crops like cotton, redgram, groundnut, linseed, sunflower, cowpea. 5. Use of methyl bromide @ 200 kg / ha as a fumigant, which is costly 6. Post emergence spray of 2,4-D @0.75-1.0 kg a.i. / ha gives moderate control.

Harvesting and threshing

When the grain is ripe and hard, the crop is to be harvested (i.e. , when the grains become hard and contain less than 25% moisture, they are considered fully ripe for harvesting). Generally, the irrigated crop matures later than dry crop. The plants are pulled out with the roots, cut at the base with sickles; when the crop is of short height are where mixed cropping is practiced, the ears alone are harvested first, leaving the stalks to be cut at a future date. The harvested plants are allowed to dry in the field for 3-4 days and the ears are then removed. The straw is kept in stacks in the field for a week for complete drying. Then it is carted and

stacked in the yard.

Sorghum grown for fodder purposes should be harvested either up to or at 50% flowering. Younger jowar plants possess a high hydrocyanic acid (HCN) content which is poisonous to the animals. Further, there is a sharp decline in the protein content and digestibility of nutrients beyond the flowering stage

In case of multi cut varieties – first cutting: 2 months after sowing

-Subsequent cuts: 30-40 days after the first cut

Threshing of the dried ears is done by beating with sticks or trampling under the feet of cattle. Stone rollers are also used for this purpose. The grain has to be winnowed, cleaned and dried to reduce the moisture to about 12-13 %. Threshing machines are also available.

Sorghum effect: Sorghum is an exhaustive crop. It removes more amounts of nutrients. So, two exhaustive crops like sorghum and cotton should not follow each other. Instead pulse crop can follow sorghum. It was experienced that some of the succeeding crops to sorghum do not thrive well due to some toxic effect left over by the jowar crop. This can be counteracted by good manuring of the succeeding crop with FYM and by green manuring with indigo or wild indigo or crop rotation or sorghum mixed cropping.

CROPPING SYSTEMS:

North India -(i) Sequences

Sorghum - Wheat

Sorghum - Wheat- greengram

Sorghum - Wheat – Cowpea

Sorghum – Pea

Sorghum - Safflower/ Sunflower

(ii) Mixed cropping

Sorghum + Soya bean

Sorghum + Pigeonpea

Sorghum + Greengram/Blackgram

South India - (i) Sequences

Sorghum- Cotton

Sorghum - Rabi sorghum

Sorghum - Tobacco

Sorghum - Finger millet - Groundnut

Groundnut - Rabi sorghum

(iii) Mixed cropping(kharif)

Sorghum+pigeonpea

Sorghum+greengram

Sorghum+blackgram

Sorghum+cowpea

Mixed cropping(rabi)

Sorghum+safflower/ sunflower

The average grain composition of sorghum grain contains Protein : 7.4 – 14.2%, Lipids : 2.4 – 6.5%, Carbohydrates : 70 – 90%, Fibre : 1.2 – 3.5% and different minerals like Ca, P and Fe.

Compared to other cereals, sorghum protein is deficient in lysine and rich in leucine. Lysine is required for bone formation. Children are more susceptible to lysine deficiency than adults. (The sticky nature of cooked rice is determined by the relative proportion of amylo protein and amylase. The main protein in rice

is Oryzenin. Among amino acids, the glutamic acid content is highest in rice which is also rich in lysine.)

YIELD ATTRIBUTES:

1. Number of panicles/unit area
2. Length of the panicle (cm)
3. Number of filled grains/panicle
4. Test weight or 1000 grain weight

Yield is the function of above yield attributing factors.

YIELD: Rainfed: 20-25 q/ha, Irrigated:50-60q/ha

Lecture 11

Chapter No. 4

PEARLMILLET /BAJRA (*Pennisetum glaucum* L.)

English: Pearl millet and Other names: Cat tail millet, candle millet, Spiked millet, Bulrush millet, dark millet etc. Bajra is one of the major coarse grain crops and is considered as poor man's food. It provides staple food for the poor in a short period in the relatively dry tracts of the country. It is the most drought tolerant crop among cereals and millets. Pearl millet is endowed with greater ability to withstand harsh climatic factors, and still yield substantially. Globally, it occupies around 27 mha. The grain of bajra is superior in nutritive value to Sorghum grain but inferior in feeding value.

Bajra grains contain about :

Moisture - 12.4%

Protein - 11.6%

Fat - 5.0%

Carbohydrates - 67%

Minerals - 2.7%

Bajra is cooked like Rice or Chapaties are prepared out of flour (like maize or sorghum), It is also used as feed for poultry and fodder for cattle.

ORIGIN:

Most of the Scientists believe that the primary centre of origin of bajra is Africa from where it spread to India and other countries.

Distribution:

Bajra is grown mostly in tropical climate. It is widely grown in Africa and Asia. The important Bajra growing countries are India, Pakistan, China and South East Asia.

In India, except in West Bengal and Assam, it is grown throughout the country. It is generally grown in areas of low rainfall and in poor soils. Rajasthan, Maharashtra, Gujarat, U.P and Haryana account for 87% of the total area. About 78% of the production comes from these states. India is the largest producer of bajra.

	Area	Production	Productivity
India ----	9.1 mha	7.3 mt	780 kg/ha

<u>Rank</u>	<u>Area</u>	<u>Production</u>	<u>Productivity</u>
I	Rajasthan	Rajasthan	M.P
II	Maharashtra	Gujarat	Haryana
III	Gujarat	Maharashtra	Gujarat

SOILS

Bajra can be grown on a wide variety of soils, but being sensitive to water logging, it does best on well drained sandy loams and clay loams. Bajra is sensitive to acidic soils. It is grown successfully on black cotton soils, alluvial soils and red soils of India.

LAND PREPARATION:

The crop needs very fine tilth because the seeds are very small. It is essential to do the summer ploughing by mould board plough and after the onset of monsoon the field should be harrowed twice (or) thrice or ploughed by country plough. Care should be taken to remove all the weeds and stubbles from the field and if

possible the field should be levelled and drains should be provided in the field.

SEASON, SEEDS AND SOWING:

Sowing time:

Kharif : June –July, Rabi : Sept –Oct, Summer :First fortnight of January

Avoid late planting beyond July 15th (In case, sowing is delayed there is a drastic reduction in yield due to more incidence of diseases like downy mildew or ergot, restricted vegetative growth of the crop, high rate of mortality and poor grain setting).

Seed Rate:

4.0-5.0 kg/ ha (If sown by drilling)

2.5-3.0 kg/ha (If sown by dibbling method)

Spacing: 45x15 cm

Seed treatment: Seed should be treated with thiram or captan @ 3g/kg of seed.

Method of Sowing: Broadcasting, Drilling, Dibbling and Transplanting. Of these, Drilling is most popular. Thinning and gap filling should be done at 10-15 DAS.

Depth of Sowing: 2 to 3 cm

Transplanting is done, in case, if sowings are delayed due to late onset of monsoon or heavy and continuous rains at the time of sowing. Transplanting gives higher yields as compared to direct sowing. 3-4 week old seedlings are planted @2/hill. Under South Indian conditions, summer bajra is usually grown by transplanting.

Advantages of transplanting

1. Transplanted crop matures early and produce more tillers and ears due to better growth.
2. Gives higher yields than direct seeding.
3. Optimum plant population is ensured.

Management of over aged seedlings

In case of seedlings having age of less than 20 days, the tillers arise from the basal nodes 'just below the ground' and most of the tillers put forth ears at the same time. When aged seedlings are transplanted, tillers arise from the internodes 'above the ground'. This makes the plant susceptible to lodging.

To overcome this, the ear of the main culm is pulled nipped followed by top dressing of nitrogenous fertilizers and copious irrigation which induces profuse tillering from the basal nodes.

MANURES AND FERTILIZERS

FYM @ 5t/ha should be applied and mixed well in to the soil about 20 days before sowing. Fertilizer schedule is as follows:

Rainfed crop : 50 to 60 -30 -20 kg N, P₂O₅, K₂O/ha

Irrigated crop : 100 to 120 - 40 -20 kg N, P₂O₅, K₂O/ha

Half dose of nitrogen, full doses of phosphorus and potassium should be applied at the time of sowing. The remaining N is applied in 2 splits. Once at the time of thinning (3 to 4 weeks after sowing) and the rest at ear formation stage.

WATER MANAGEMENT

As bajra is a rainfed crop, there is hardly any need for irrigation. Irrigate the crop if there are no rains. Generally, two irrigations during the growing period of the crop are enough. If moisture is limiting, irrigation must be given at the time of earhead emergence because it is the most critical stage for moisture stress. Bajra does not tolerate water logging. So do not allow rain water to stand in the field for more than few hours. Proper arrangement for draining the excess water must be made. Total water requirement is 450-550 mm and W.U.E. is 8.0 kg/ha.mm of water.

WEED CONTROL

The damage due to weeds is severe during 3-5 weeks after sowing. Intercultivation by hand hoe or wheel hoe should be done at 3-5 weeks after sowing. However, sometimes due to unavailability of labour or soil being too wet to permit manual weeding, timely weeding becomes difficult. Under such conditions the only effective way to control weeds is the use of herbicides.

Pre-emergence application of Atrazine or Propazine @0.5 kg per/ha in 600 litres of water controls most of the monocot and dicot weeds.

HARVESTING AND THRESHING:

Harvest the crop when grains become hard and contain about 20% moisture. Harvesting is done by cutting the entire plant or removing the earheads first and cutting down the plants later on. The ear heads after harvesting, should be dried in the sun. The grains are separated either by beating the ear heads by sticks or by trampling by bullocks. The threshed grain should be cleaned and dried in sun to bring the moisture content down to 12% for safe storage.

CROPPING SYSTEMS:

Sequential cropping: Pearl millet- Ground nut

Pearl millet - Cowpea

Pearl millet- Pigeonpea

Pearl millet – Barley

Pearl millet- Wheat

Pearl millet- toria

Inter cropping system : Pearl millet + Groundnut

Pearl millet + Cowpea

Pearl millet + Pigeonpea

Pearl millet + Castor

Pearl millet + Sesame

Pearl millet + Mungbean

Pearl millet + Urdbean

Reasons for low yield of coarse cereals:

1. Marginal lands are used for their production than other cereals.
2. They are confined to small production units
3. They are often grown as intercrops
4. uncertain precipitation trends
5. Limited commercial demand

VARIETIES:-

BJ-104, BK-560, BD-111, MBH-110, ICMH-451

COMPOSITS: VIJAYA, NAGARJUNA, ICTP -8203, BALAJI, VISAKHA, WCC-75, ICMV -155, ICMV 221

SYNTHETICS: MUKTA, MALLIKARJUNA(PBS-1), APS-1 (ANANTHA), ICMS- 7703

YIELD ATTRIBUTES:

Total number of tillers per unit area, Number of productive tillers per unit area, Length of the earhead, Number of filled grains per earhead and test weight.

YIELD: For rainfed crop grain yield is 12-15 q/ha and dry stover 70-75 q/ha and for irrigated condition grain yield is 30-35 q/ha and dry stover is 100q/ha.

Lecture 12

Chapter No.5 FINGERMILLET (*Eleusine coracana*)

English name :Finger millet, Birds foot millet, African millet

Finger millet is commonly known as Ragi. In eminent vedic literature ragi is mentioned as ragika. It is an important minor millet grown in India. It is a staple food crop in many hilly regions of the country. In fact, it is the main cereal crop for monsoon season in some hilly areas. It is predominantly grown as a dry land crop in Karnataka, Andhra Pradesh, and Tamil Nadu. Finger millet contributes nearly 40% of total small millet produce of India, occupying nearly 3.2 million ha. Ragi is relished mostly by the rural population of southern India for the nutritious meal it provides.

It is grown both for grain and forage. In northern hills, grains are eaten mostly in the form of ‘Chapaties’ and halwa. In South India, grains are used in many preparations like cakes, puddings, sweets etc.

- Germinating grains are malted and fed to infants also.
- It is also good for pregnant woman
- It is a nutritive food for adults of different ages.
- It is good for persons suffering from diabetes.
- The green straw is suitable for making silage, which gives sweet smell and consumed by cattle without wastage.
- Besides vitamin A&B phosphorus is also present in smaller quantities.
- The grain is nutritionally rich and the richest in ‘calcium’

NUTRITIONAL VALUE- It contains about 76.32% of carbohydrates, 9.2% proteins, 1.29% fat, 2.245 minerals, 3.90% ash and 0.33% calcium.

ORIGIN

According to Decandoll (1886) Finger millet probably originated in India. It might have originated from *Eleusine Indica*, a grass that occurs in many parts of North India. It is supposed to have spread from India to Abyssinia and rest of Africa.

Vavilov (1951) – considers *Eleusine coracana* to be of African origin.

It is grown in India, Africa, Malaysia, Srilanka, Japan & China. India is the leader in the area of finger millet improvement.

AREA & PRODUCTION

Total area of India is 2.50 m.ha with a production of 2.20 mt. Karnataka is the major state for finger millet production in India, accounts for 55.6% of the area and 60.7% of production in the country.

ADAPTATION

It is a crop of tropical and subtropical climate and can be grown successfully from sea level to an altitude of 2100 mts on hill slopes as well as in plains. It is a hardy crop. It is grown in areas having annual average rainfall between 500 to 1000 mm. In regions of higher rainfall it can be raised on well drained soils as a transplanted crop. It can be grown under rainfed as well as irrigated conditions.

SOILS

It can be grown on a wide variety of soils ranging from very poor to very fertile soils. It thrives best on well- drained loam or clay loam soils. Clayey soils, heavy black cotton soils, gravelly and stony soils with poor fertility and drainage are not suitable. It can tolerate salinity better than other cereals.

SEASON

Finger millet is not a season bound crop. So, it can be grown through out the year, if water is available, The main seasons are

1. Punasa Ragi (or) Burada Chodi

Finger millet is grown in wetlands, prior to planting of rice in slushy conditions by taking advantage of

monsoon rains in Srikakulam and Visakhapatnam Dist. Short duration varieties (AKP -2) are preferred for this season. Twenty five percent Ragi in above districts is under this season (May-Aug).

2. Main Season (or) Pedda Panta

The main area under Ragi crop during this season (Aug-Nov) accounts for 50% area of Srikakulam and Visakhapatnam. Suitable varieties are AKP -7 and Kalyani (WR – 652)

3. Pyru season

Remaining 25% of area is under pyru season. (Nov/Dec – Feb/ March). As the crop is grown under assured irrigated conditions, the yields are high. VZM-2 is recommended.

LAND PREPARATION

The first ploughing with mould board plough should be done immediately after the harvest of the previous crop. With the onset of monsoon, field should be ploughed with local plough 2-3 times and finally levelled.

SEEDS & SOWINGS

Sowing is done by Broadcasting, drilling, sowing in shallow furrows and transplanting.

1. Broadcasting

In dry lands sowing is done by broadcasting and seed is covered by working with blade harrow which is generally practiced in coastal districts of A.P & T.N. Seed rate is 8 Kg/ ha

2. Drilling

Finger millet is also sown by bullock drawn seed drills in shallow depths of 3-4 cms. This is generally adopted in Rayalaseema & Telangana regions of A.P and Karnataka.

3. Sowing in shallow furrows

In Karnataka, seeds are mixed with cattle manure and sown in furrows drawn by 3 tined drills. Furrows are covered by blade harrow. Seed requirement in this method is higher than normal recommendation.

4. Transplanting

It is practiced under assured irrigation. 1) Ridges and furrows 2) Flat bed method.

Seeds are raised in nurseries and after 20 days, seedlings are ready for transplanting in main field.

SEED RATE AND SPACING

Seed rate: 4-6 kg/ha.

15x15cm – for long duration varieties

15x10 cm – for Short duration varieties.

MANURES & FERTILIZERS

For Nursery: FYM : 10t/ha Incorporation before sowing
40-40-40 kg N, P₂O₅ and K₂O/ha

For mainfield: FYM: 10t/ha – Before sowing
60-30-30 kg N, P₂O₅ and K₂O/ha

N is applied in 2 Splits

1. At the time of transplanting – ½ dose of N along with full dose of P and K.
2. Remaining dose of N at 30 DAS.

IRRIGATION:

Ragi sown during *Kharif*, generally does not need any irrigation. Adequate moisture should be provided at the time of flowering and grain setting stages. It can not tolerate waterlogged conditions. Hence, drainage facilities should be provided. After establishment of seedlings for a week or 10 days, irrigation should be cut

off. This helps in hardening of seedlings and for vigorous and healthy growth.

WEED MANAGEMENT

It is essential to control weeds in the initial stage of plant growth and development. Weeding should be done with hand hoe after 25 days of sowing. 2-3 hoeings would be sufficient to control the weeds in problems areas. Hand weeding gives satisfactory control of weeds. Pre emergence herbicides like metoxuran 0.75 kg ai/ha + one hand weeding gives excellent control of weeds.

HARVESTING OF THRESHING

The crop matures in about 4-4 ½ months depending on the tract and the variety. Irrigated or transplanted crop produces more tillers than that grown in drylands. Earheads on main shoots matures earlier than tillers. As & when earheads are matured harvesting is done generally 2 or 3 times. Harvested earheads are kept on floor and covered by gunny bags or tarpaulins which brings change in colour to all the grain in earhead.

It is dried & threshed by stone roller or cattle.

Varieties- Kalyani, Sarada, Godavari, Simhadri, Ratnagiri, Hamsa and Co 9 (12% protein) are some developed varieties. The other varieties are AKP-2, Suraj, Padmavathi, VZM-1, Sapthagiri, Maruthi, Gauthami, Bharathi, Champavathi etc.

Cropping System:

Finger millet in rainfed conditions is cultivated generally as a mixed crop with sorghum, pearl millet and a variety of oil seeds and pulses. In hilly areas it is grown mixed with soybean. Under irrigated conditions, it is grown in rotation with crops like tobacco, vegetables, turmeric, Bengal gram, linseed, mustard etc.

Some of the most prevalent cropping sequences are

- Finger millet - Bengal gram
- Finger millet - Mustard
- Finger millet - Tobacco
- Finger millet - Groundnut
- Finger millet - Sugarcane
- Finger millet - potato – maize
- Finger millet - potato – maize
- Finger millet - potato – finger millet
- Finger millet - rice

YIELD ATTRIBUTES: Number of plants per unit area, number of tillers per unit area, number productive tillers per unit area

YIELD

Rainfed: 7- 8 q/ha - grain

11-18 q/ha – fodder

Irrigated: 30-35 q/ha - grain

35-50 q/ha – fodder

Lecture 13

Chapter No.6 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
- In 1992-93, Technology Mission on Pulses was started by 2 sub terms.
- NPDP : National Pulse Development Programme.
- SFPP : Special Food grain Production Programme.
- Per capita requirement of Pulses :
- 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

Importance of Pulses:

- They are rich source of proteins
- The average protein available in pulses is 20-30%. Pulses are rich in ‘Ca’ & Phosphorous. They are also good sources of Vitamins.
- Pulses provide a superior quality of fodder & feed to the cattle, as they are good forage crops with proteins and minerals content.
- They are considered as good green manure crops because of rich canopy development.
- They improve the soil fertility by biological nitrogen fixation
- The nitrogen needs of pulses is low & minimizes the N requirement of succeeding crop by around ¼ of its total requirement.
- Pulses help in the Soil and Water conservation.
- They improve the physical condition of the soil like soil aeration, water holding capacity by improving microbial population, breaking of hard pans and moisture retention.
- Pulses are important in crop mixtures / rotation. They act as catch crops.
- 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.

PULSES -REASONS FOR LOW YIELDS OF PULSES IN INDIA

In spite of the importance of pulses in our daily diet, the production of pulses has not yet increased proportionately as that was increased in the cereal production. Looking the situation being a national level problem, it is important to analyse different constraints leading to low productivity of pulses. The following have been realized the major constraints in pulse production.

I. AGRONOMIC CONSTRAINTS:

- i) Improper sowing time: The pulse crops gets last preference and priority in the sowing schedule. Late planting not only results in poor growth but also leads to high attack of sucking pests. If sowing of pigeon pea is delayed beyond 20th July, there a is significant reduction in yield. In case of mungbean delay in sowin g beyond August reduced the yield to the extent of about 600 kg/ha. A late sown crop is more prone to serious damage by pod borer.
- ii) Low seed rate: Farmers hardly use any recommended seed rate. Very poor plant population has been

reported in case of arhar, moong and urd in the farmers fields. 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 and urd.

iii) 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

iv) Inadequate interculture: Farmers hardly follow interculture in these crops. Line sowing helps for interculture operations through bullock drawn implements and hand hoes etc. Pulse crops suffer due to the infestation of weeds because of their initial slow growth.

v) Insufficient irrigation: Though pulse crops are drought tolerant, one or two protective or life saving irrigations are required, particularly in rabi pulses. For Kharif pulses also, protective irrigations are essential during the period of dry spell. Farmers give priority for irrigation to cereals and millets. Irrigations, if provided, wherever possible, enhances production, particularly at the pod development stage of pulse crops.

vi) Sowing under utera cultivation: Large area under pulses is sown as utera without cultivation and inputs. The yields of such crops is very poor.

vii) Poor management conditions: The concept that pulses can grow and produce better yields on marginal lands without any inputs and management is not correct. Being protein rich crops, pulses require more energy input per unit of production as compared to cereals. But on the contrary, they are grown under conditions of energy starvation resulting in poor yields.

viii) Non-availability of efficient *Rhizobium* culture: In general, *Rhizobium* culture is the cheapest input with high cost: benefit ratio: Symbiotic nitrogen fixation takes place very effectively if the natural relationship is established between the legume cultivar and its specific strain of *Rhizobium*. However, use of *Rhizobium* culture is not getting popular among the farmers because unlike fertilizers, the specific cultures of desired quality are not readily available in the market. Many times spurious cultures are supplied to the farmers which are not effective and the farmers lose faith in using *Rhizobium* culture.

ix) 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.

x) Losses due to diseases and insects pests: Pulses in general are susceptible to a large number of diseases and insect pests, which cause heavy losses. 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. For yield stability and wider adaptability of genotypes, it is essential that varieties with multiple resistance to these major diseases are identified, adopted and popularized. Such multiple resistant varieties are wanting among the pulse crops.

II) GENETICAL CONSTRAINTS:

The major constraints of pulse production in the country is the lack of suitable genotypes with higher yield potential on farmer's fields. Some other genetical constraints are,

- Lower productivity
- Non synchronous flowering/fruitletting
- Non-responsiveness to good management
- 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.)
- Indeterminate growth habit of most of the pulses
- Instability in performance
- Lack of good and quality and certified seed [SRR (seed replacement ratio in pulses is 2.5% against the recommended SRR i.e. 10%]
- Non-availability of drought and waterlogging resistant varieties.

III. PHYSIOLOGICAL CONSTRAINTS:

Besides the agronomy and genetical constraints, physiological constraints are also plays a major role in the low production and productivity of pulses. Some of the physiological constraints are:

- Low harvest index
- Low sink potential [source=leaf, drymatter; sink=seed]
- A lot of dry matter goes for production of stalk, with the result the harvest
- Index is very low. For example, in pigeonpea out of about 15,000kg total dry
- Matter produced, the grain share was only 10 percent. On the other hand, in
- Case of most of dwarf wheats, the grain share is even more than 33% of the
- Total dry matter.
- Flower drop is another physiological problem in pulse crops. This results in poor pod setting and consequently low yield.
- Non-responsiveness to fertilizers.
- Photo and thermosensitive phenomenon.
- Lack of short duration varieties i.e. long duration gives low per day production.

STRATEGIES FOR IMPROVING THE PRODUCTIVITY OF PULSES:

The problem of short supply of pulses was brought to notice of I.C.A.R and an integrated All India Co-ordinated Programme was started in 1972-73 in collaboration with U.S. Department of agriculture for the pulse improvement work in the country. The main emphasis for increasing pulse production is to be laid on following points:

1. Bringing an additional area under short duration high yielding varieties to fit in multiple cropping programmes to be grown as catch crop.
2. Developing new cropping systems like companion cropping, mixed cropping (or) intercropping for growing pulses between widely spaced crops such as sugarcane, maize, potato, cotton, arhar, groundnut, bajra and jowar etc. both under irrigated and rainfed conditions.
3. Evolution, multiplication and use of improved seeds of various pulses.
4. Adoption of efficient plant protection measures.
5. Basal placement of phosphatic fertilizers and treating the seeds with Rhizobium culture.
6. Growing pulses on relatively fertile lands rather than growing them on marginal and submarginal lands.
7. Adoption of improved package of practices like line sowing, control of weeds, harvesting at right time or at physiological maturity to avoid splitting of pods and thereby minimising shattering losses.
8. Granting subsidy on Government loans to the growers and providing improved seeds, fertilizers and plant protection materials on concessional price to the farmers.
9. Evolution of better plant-types of pulses for boosting pulse production.

The varieties thus developed are characterised under:

- a) Non-spreading and erect types.
- b) Thermo and photoinsensitive.
- c) Early maturing
- d) Responsive to applied inputs with high yield potentials.
- e) Fairly resistant to water logging, insect pests and diseases.
- f) Resistant to drought and frost.
- g) High nutritional qualities.

Rice fallow production Technology and Constraints:

Sowing of sprouted seeds short duration pulses particularly Green gram and Black gram just 3-4 days

before harvest of paddy is known as relay cropping. Popularly termed as Rice fallow pulses.

The seed rate recommended in the system is higher than that of direct sowing of Black gram and Green gram. The rice fallow pulses are grown with the available residual soil moisture and residual fertility. Before sowing of pulse seed alleys are made in the paddy field for removal excess water as well for easy sowing and proper distribution of seeds in the field.

Lecture 14

REDGRAM (*Cajanus Cajan*)

Common names- Arhar, tur, redgram, congo pea, gungo pea, no eye pea
Pigeonpea is the second most important pulse crop of India after chickpea.

AREA, PRODUCTION & PRODUCTIVITY:

- * India ranks first with about 90% of the world area and 85% of production aving 3.61 mha of area, 2.7 mtonnes of production and 747 kg/ha of productivity.
- * Pigeonpea ranks sixth in area and production in comparison to other pulses.

Crop duration-

Long duration varieties (180-270 days), Medium duration varieties(), Early varieties(120-150 days), Extra early varieties(less than 120 days).

* For kharif , never choose early and extra early varieties as the rains coincide with flowering and pod formation.

* Generally medium duration varieties are recommended for kharif.

* Late maturing varieties during kharif may suffer from terminal stress.

* In A.P., LRG-30 (PALNADU) is t he promising variety both in kharif and Rabi, ICPL 85063 (Lakshmi) both for kharif and Rabi.

VARIETIES FOR KHARIF: Duration 170-180 days

ICPL 332 (Abhaya)

ICPL 8719 (Asha)

Maruti(LRG-41)

Early maturing varieties for Rabi CPL-87

ICRISAT varieties – ICPL 870, ICPH-8 (Hybrid variety)

ORIGIN: Africa

DISTRIBUTION: The important Pigeonpea growing states are Maharastra, U.P., M.P, A.P & Karnataka. In India, Maharastra, U.P & M.P together occupy 62% of the area & contribute 73% of total production.

SOIL: It can be grown on a wide range from Sandy loams to clay loams. The crop performs well on fertile well drained loamy soils. Saline, Alkaline and waterlogged are not suitable.

CLIMATE:

- It is a quantitative short day flowering response plant i.e. the onset of flowering is hastened as day length shortens.
- It is grown throughout the tropical, sub-tropical & warmer regions of the world between 30°N & 35°S latitude.
- It tolerates heat and drought. It prefers moist and warm climate during vegetative period and cool and dry period during reproductive stage.#
- It is susceptible to frost.
- The cloudy weather and excessive rainfall during flowering damage the crop to a great extent.

SEASON:

Kharif: June – July

Rabi : Sep – Oct

The sowing time depends upon the duration of variety and rainfall pattern of the region, Early sowings are always better.

Sowings should be planned in such a way that flowering and pod formation should not coincide with peak rainy period.

SEED TREATMENT:

Seed treatment with fungicides like Bavistin 1g/kg seed captan or Thiram @2.5 g/kg before sowing effectively controls fungi and reduces incidence of both seed and soil borne fungi. Seed treatment with Rhizobium culture can increase the yield upto 20-30%.

SEED RATE:

Kharif: 12-15 kg/ha

Rabi : 45 kg/ha

METHOD OF SOWING: Seeds are sown behind the plough or with the use of seed drills. Plant population depends on:

1. Sowing time: For Kharif, plant population is less than rabi because of more canopy growth.
2. Fertility status of soil: Higher plant population can be used under fertile soils than on infertile soils.
3. Rainfall pattern: In regions which is having well distributed rainfall, maintain high plant population than in the areas with low rainfall.
4. Varieties: Variety with less branching require higher plant population.
Duration of the crop: Longer duration varieties require less plant population because of more canopy development.

SPACING: Short duration-60x10cm; Medium & Long duration 75x20 cm.

DIFFERENCES BETWEEN:

PARAMETER	KHARIF REDGRAM	RABI REDGRAM
Season	June to July	Sep – Oct.
Seed rate	12-15 kg/ha	45 kg/ha
Spacing	60x10cm-sole crop 1.2 to 1.5 m for (Intercrop)	45x10cm for sole crop.
Duration	160-180 days	120-125 days
Plant height	>2m	1-2m
Seed size	Big	Small
No.of pods/plant	More	Less
Pest & Diseases	More	Less
Yield level	10-15 q/ha	8-12 q/ha.

MANURES & FERTILIZERS:

MANURES: 5 tons/ha of FYM in Kharif.

NITROGEN: 20kg/ha – long & Medium duration varieties PHOSPHOROUS: 50 kg P₂O₅/ha for phosphorous deficient soils at sowing.

POTASSIUM: 20kg K₂O/ha for potassium deficient soils by placement at sowing.

BIO -FERTILIZERS: For early and effective nodulation, seed treatment with Rhizobium is recommended.

IRRIGATION:

- The critical periods for Irrigation are flower-initiation and pod-filling stages.
- Intensive cropping of pigeonpea can also be achieved under tube well irrigation, arising at a highest production of 4 tons/ha. Redgram grown in Kharif does not require any irrigation.

WEED MANAGEMENT

Pigeonpea is a slow -growing crop during the first 6-8 weeks, and 2 harrowings during this period would be adequate to check weed growth. The herbicides recommended are pre -emergence application of Alachlor (Lasso) @ 1.5 kg a.i/ha, Fluchloralin (Basalin) @ 1.5kg a.i/ha.

HARVESTING, THRESHING & PROCESSING:

The redgram is said to be indeterminate in growth habit where the flowering goes on continuously over the months on the same plant. Flowering, unripened pods & already, developed pods at the same time Hence, on the plant will be seen the crop is harvested in 2-3 pickings.

- The whole plants are cut when most of the pods are dried.
- Then the plants are bundled and staked for one week for the purpose of post harvest ripening of unripened pods after that the dried pods are beaten with sticks and then the seed is separated.
- Since seeds are consumed in the form of split cotyledons and dal it is better to go for processing before storing.
- Power operated hullers or processors are available for splitting of seeds in to dal.
- The dehulled operation is usually performed in 2 steps: the first involves loosening the husk from Cotyledons and the second involves removing the Husk from Cotyledons and splitting them using a roller machine.

YIELD ATTRIBUTES:

- Plant population/unit area
- Plant height
- No. of pods/plants

YIELD: For irrigated – 15-18 qt/ha and Rainfed – 10-15 q/ha

Inter/Mixed cropping- 5 - 6 qt/ha

UTILITY VALUE:

- Dry seed is dehulled & the split cotyledons (dal) are cooked to make thick soup primarily for mixing with rice (dal-rich source of protein).
- The ability of pigeonpea to produce economic yields under soil moisture deficit makes it an important crop of dry land agriculture.
- The husk of pods after threshing is also used as cattle feed.

CROPPING SYSTEMS:

Intercropping:-

Sorghum + pigeon pea

Maize + pigeon pea

Pigeonpea + groundnut

Sequential cropping:

Pigeonpea – Wheat/mustard – greengram

Pigeonpea + greengram – wheat/mustard

Maize – pigeonpea.

Lecture 15

Chapter No.7 GREENGRAM (*Vigna radiate*)

Family: Leguminosae

Common Indian Name: Mung, mung bean, golden gram

- Greengram is the third most important pulse crop of India after chick pea and pigeon pea.
- The protein content in Greengram is 24 percent.

Economic importance:

- Pods are used as vegetables.
- It is highly digestible pulse crop than any other pulse crop.
- The husk and haulms are used as good fodder for cattle.
- The left over seed coat i.e testa is also used for milch cattle.
- Due to its shorter duration, it can be fitted well in several multiple cropping systems.
- It is also grown as a green manure crop.
- Inclusion of greengram in cropping systems improves soil health and fertility.
- Being a close growing crop, it helps in reducing soil erosion and also checks weed growth.
- Being a legume crop, it fixes biological nitrogen.

Origin and distribution:

- The origin of greengram is India
- Greengram is widely cultivated throughout Southern Asia. Myanmar, Pakistan, Thailand, Srilanka, Indonesia and China are the principal countries of greengram cultivation.

Soils:

Greengram is cultivated on a wide range of soils from sandy loams to black cotton soils. In North India, the crop is cultivated on well drained loamy soils where as in South India. It is cultivated on red soils. The crop doesn't with stand waterlogging. Optimum soil pH: 6.5-7.5. Fairly tolerant to soil salinity.

Climate:

Greengram is a tropical pulse crop largely grown under semi arid and subtropical environment. It is well suited for all rainfed areas with Annual rainfall of 600-1000mm. It can tolerate high temperatures upto 40°C, It is hardiest among all the pulses]

Preparation of land:

There is no need for a fine seed bed preparation 1 or 2 ploughings followed harrowing is adequate for a kharif crop. Greengram is cultivated on deep soils during Rabi on Kharif fallow soils. There is no tillage for rice fallow (Relay Crop) as the seed is broadcasted in standing crop of Rice about a week before its harvest.

Seeds and Sowing :

Seed Rate: Sole Crop	----	12-15 Kg/ha
Green manure	----	25-30 Kg/ha
Summer Crop	----	25-30 Kg/ha

Rice fallow pulse crop	----	30-35 Kg/ha
Method of sowing: Broad casting		(Relay Crop)

Drilling in rows (or) furrows behind a plough for direct sown crop.

Dropping the seed in furrows	----	KERA (or) PORA
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Optimum seed depth for sowing ---- 5-7cm

Spacing: 30X10 cm

Plant population: 3.33 Lakh plants/ha

VARIETIES:

Khariff-LGG450, LGG 407,LGG 460, WGG 37, MGG 295,M2 267, Pusa 105, MGG 347, MGG 348,PDM54.

Rabi --LamM2,LGG 460, LGG 410, Pusa 105, LGG 407, MGG 295, WGG 37, TM96-2

Summer & Spring Season — Pusa Baisakhi and Co-4

Rice fallows --- LGG 410

Tolerant to high temp. --- Padma, Sunaina & Co-4

Early maturing (60-65 day) --- Pusa Baisakhi, k851,PS16,
Padma, Sunaina & Co-4,
Pusa Bold (Vishal),

First mung variety released in Orissa during 1980: Dhuli

First Mung bean variety released in India during 1948: T1.

Resistant varieties:

YMV resistant- LGG 407,LGG 460,WGG 2,WGG 37,PDM 54,ML 267

Leaf Curl resistant- LGG 460, MGG 295

Angular Black Leaf Spot resistant- LGG 407, WGG 2

Powdery Mildew resistant- TM 96-2, TARM 18

Season: Kharif, Rabi and Summer (early duration i.e.60 days and less incidence of pest and diseases)

FERTILISERS:-

Rhizobium inoculations considerably minimize the need for nitrogen fertilizer application.

Rainfed Crop: 10 kgN/ha (Starter dose (or) booster dose) & 30 P₂O₅ Kg/ha (Basal)

Irrigated Crop: 20 N kg/ha (Starter dose) & 40 P₂O₅ Kg/ha (Basal)

Nearly 40N, 10P₂O₅ & 15 K₂O Kg/ha is removed by 1 tonne of Greengram.

Biofertilizers:For Mung bean, 500 g of Rhizobium culture is sufficient for seeds required to be sown in 1 ha i.e., 2.5 packets/ha(Since 1 packet=200 g). Greengram fixes 20 Kg N/ha

Greengram associated with VAM (Vesicular Arbuscular Mycorrhiza) Which is a PO⁻³₄ absorber, absorbs greater amounts of phosphorous.

Water management:

· For Kharif crop, irrigation is not required but winter & summer crop require 2-3 irrigations.

· Ricefallow greengram crop is not irrigated

Critical stages:Flower initiation (35 DAS), Pod filling (55 DAS)

· Total water requirement: 300 – 400mm

· Water logging at flowering & pod filling reduce the yield upto 75% and more.

Weed Management:

Critical Period for weed competition is 35 DAS

Herbicide recommended is Fluchloralin (Basalin) @ 1.5 Kg a.i/ha

Production constraints of Greengram:

1. Moisture stress: Generally kharif sown crop suffers from moisture stress due to intermittent dry spells during the growth phase. Hence, drought tolerant varieties may be recommended like PDM-54,MH 309, K-851.

2. Preharvest Sprouting: Kharif sown crop matures in August (Or) September, usually the crop is caught in rains at the time of harvest. Hence there is a sprouting of seeds in the pods causing heavy losses both in terms of yield and quality. The variety resistant to preharvest sprouting is LGG-450.
3. Non synchronous in maturity: It is usually harvested by pickings. Most of the varieties are Non-Synchronous in maturity. Hence, harvesting is done in 2-3 pickings. Varieties tolerant to non-synchronous maturity are PDM 54, MH 309 and Pusa 105 are Susceptable to diseases.

Major pest and diseases are: YMV, LCV, powdery mildew, angular black leaf spot, thrips, Maruca pod borer.

Harvesting : For kharif crop, the harvesting is done by picking the pods. For Rabi & Summer crops, harvesting is done by cutting the whole plant to the base.

Threshing and processing: The produce is cleaned and sun dried to about 12 percent moisture content and then stored. Greengram is primary consumed in the form of Dhal.

Green pods are also used as vegetables. Sprouted seed is consumed as salads. Dry seed is boiled and used in soups, made into porridge with rice and wheat. The flour is used in cakes . Starch is used in making noodles.

Yield and Yield Components :

Major yield components are number of pods per plant, number of seeds per pod and test weight.

Cropping systems:

Paddy followed by Greengram

Paddy- Paddy- Greengram

Greengram-Maghi Jowar Practiced in Khammam.

Greengram-Tobacco—followed in Black cotton soils

Greengram-Maize-Wheat

Greengram-Rice-Wheat

Greengram-Maize-Potato-Wheat

Greengram-Maize-Toria -wheat

Lecture 16

Chapter No.8 BLACKGRAM (*Vigna mungo*)

Importance:

- Consumed as dhal or split seeds, husked or unhusked
- Chief constituent of papad..
- Haulms used as fodder.
- Husk and split beans are used as livestock feed.
- Possesses deep root system binds soil particles and prevent erosion.
- Also used as green manure crop.
- Contains 25% protein, 1.83% fat, 61% carbohydrate.
- Pecularity is when ground with water develop mucilaginous character giving additional body to the mass.
- Husked dal is ground in to a fine paste and allowed to ferment with rice flour to make dosa or Idli.

Origin: India is considered as primary centre of origin and Central Asia as the secondary centre of origin of blackgram.

Distribution: Distribution is comparatively restricted to tropical regions i.e.India, Pakistan,Bangladesh, Myanmar, Srilanka.States cultivating Blackgram in India: M.P., Maharashtra, A.P, TN, U.P,and Orissa.

Area, production and productivity

Blackgram is grown in an area of about 3.29 million ha with a total production of 1.60 million tonnes with an average productivity of 485 kg/ha.

Andhra Pradesh leads with highest area and production among states followed by Madhya Pradesh, Orissa, Maharashtra. Karnataka leads with highest productivity followed by Orissa, Andhra Pradesh. In A.P. area under Blackgram is 2.95 lakh ha. with a Production- of 2.14 lakh tonnes and productivity of 877 kg/ha.

SOIL AND CLIMATIC REQUIREMENT:

- Ideal soils with well drained loam or sandy loam.
- Generally grown in areas which receives annual rainfall of 800mm. It is a hardy and drought resistant plant and can be grown in areas receiving 650mm rainfall.
- Optimum temperature for better growth ranges between 25-35°C but it can tolerate upto 42°C.
- Grown from sea level to 1800m.
- Optimum pH range is 5.5 to 7.5.

Climate and varieties: Grown as Kharif and summer crop in North India but in South and South west , it is also grown as rabi crop.

Season

Varieties

Kharif LBG-20, LBG-623, WBG-26, T -9

Rabi (rice follow) : Krishna, LBG-611, LBG-22, LBG-648, LBG-685, LBG-645

Varieties resistant to yellowmosaic virus :U G-218, Pant-U19, DPV-88-31 Varieties resistant to downymildew: LBG-17, LBG-402, LBG-22, LBG-611

PRODUCTION CONSTRAINTS OF BLACKGRAM:

1. **Moisture stress:** Generally kharif sown crop suffers from moisture stress due to intermittent dry spell during the growth phase.
2. **Pre -harvest sprouting:** Kharif sown crops mature in August or September. Usually crop is caught in rains at the time of harvest. Hence , there is a sprouting of seeds in the pods causing heavy losses both in terms of yield and quality.
3. **Non-Synchronous maturity:** It is usually harvested by pickings. Most of the varieties are non synchronous in maturity. Hence , harvesting is done in 2-3 pickings.
4. **Susceptible to diseases:** Major diseases in blackgram are yellow Mosaic virus , leaf crinkle, powdery

mildew.

Seed rate: For kharif crop 15-18kg/ha and for rabi crop 18-20kg/ha and for rice fallow system 40-45 kg/ha.

Spacing: Dibbling –30x10cm.

On wet land bunds dibble at 30cm spacing.

Generally in A.P – In rice fallows, pulses (blackgram and greengram) broadcast in standing crop of rice 2-3 days before the harvest uniformly at optimum moisture condition.

Fertiliser application:

Rainfed : 12.5 kg N + 25 kg P₂O₅/ha

Irrigated : 25 kg N + 50 kg P₂O₅/ha.

Foliar spray of DAP and NAA (rice fallows)

- Spray 2% DAP at the time of first appearance of flower and 15 days later.

- Spray 40ppm NAA-at the time of first flowering and 15 days later.

Irrigation: Not required for Kharif crop.

For Rabi crop

1. Irrigate immediately after sowing followed by life saving irrigation on third day.

2. Irrigate at interval of 10-15 day depending on soil moisture.

3. Flowering and pod formation are critical period for irrigation.

4. Avoid water stagnation at all stages.

5. Apply KCl at 0.5% as foliar spray during vegetative stage if there is moisture stress.

Weed management: Spray fluchloralin @1.5 lt/ha or pendimethalin @2.0 lt/ha as pre-emergence 3 DAS followed by one hand weeding 30 DAS.

Harvesting & threshing:

Crop comes to maturity at 80-95 DAS. Upon ripening, blackgram pods turn from green to yellow and then to black.

In case of irrigated crop, ripened pods can be collected in one or two pickings. If plants come to even harvest, then plants are cut and spread on threshing field to dry. The plants will dry and become black and pods start splitting. The plants are then beaten using sticks and separate seeds from pods followed by winnowing to remove debris.

Yield: Rainfed: 600 -700 kg/ha, Irrigated: 1000-1300 kg/ha., Rice fallows: 500 kg/ha.

Processing:

1. Dal milling: Dal milling is one of the major food processing industry and there is net loss of 10-15% during milling.

2. Pulsing: Snack food prepared by heating and toasting/pulsing.

Cropping systems and rotations:

1. Paddy followed by blackgram.

2. Paddy-paddy-blackgram.

3. Blackgram - Maghi Jowar (Khammam)

4. Blackgram – tobacco (black cotton soils)

North India:

Maize - Wheat – Blackgram.

Maize – potato – Blackgram

Paddy – Wheat – Blackgram.

Lecture 17

Chapter No.9 GROUNDNUT (*Arachis hypogaea*)

Family : Leguminosae

Common name : Groundnut, Peanut, Monkey nut, Earth nut, Manila nut, moong fali (Hindi). In Greek language '*Arachis*' means legume and '*hypogaea*' means below ground, referring to formation of pods in the soil.

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

Economic uses

1. Groundnut oil is the cooking media for preparing different food items. It is the primary source of vegetable oil requirement to the Asian people.
2. The groundnut seed contain 47-53% oil and 26% protein and 11.5% starch.
3. The groundnut kernels are good source of all B -vitamins except B12 and vitamin E.
4. Groundnut kernels are rich in P, Ca & Mg including micronutrients like Fe, Zn.
5. Nearly 81% of the kernels are used for oil extraction, 12% used for seed purpose, 6% - raw materials, 1% - exported in terms of Hand picked selections (HPS).
6. Groundnut kernels are also used for the preparation of food products like chikkis, G.nut, milk, G.nut butter, curd including diff. bakery products
7. G.nut oil is a major source of edible oil in India. The inferior quality oil is used for making soaps, detergents, Cosmetics, paints, candles, Lubricants and some of the medicines.
8. G.nut oil is used for medicinal purposes especially for massaging polio patients & it is also used as a substitute for olive oil and also for preparation of glycerin.
9. The oil cakes are used as valuable organic manures & feeding material for live stock. It consists of 7.3% N; 1.5% P₂O₅ & 1.3% K₂O.
10. The peanut haulms contain crude protein 8–5% lipids 1–3% and minerals 9– 10%. These are used as cattle feed either in fresh or in dried stage or preparing hay or silage.
11. The peanut shells or pod walls which constitute nearly about 25% of total pod weight are used as bedding material for poultry or as mulching material during summer season to reduce the evaporative losses.
12. Shell material is also used as filler material for making mixed fertilizers and as insulation material for buildings or as fuel in boilers.
13. G.nut crop add sufficient quantity of organic matter to the soil as most of the leaves are shed just before harvesting. In some areas, G.nut is used as a green manure crop.
14. G.nut is able to fix atmospheric nitrogen @ 60 – 100 kg N /ha within 1 season.

ORIGIN

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

AREA AND PRODUCTION

Major groundnut producing countries are China, India, Nigeria, USA, Indonesia, Argentina, Sudan, Senegal and Myanmar. India ranks first in area and production contributing to 40% of the area 36% of the world production. G.nut accounts for 28% of the total area & 36% of total oilseed production in the country. The major G.nut producing states are Gujarat, A.P., T.N., Karnataka & Maharashtra

CLASSIFICATION

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

Subspecies **hypogaea**

- Variety hypogaea (Virginia type)
- Variety hirsuta

Subspecies **fastigiata**

- Variety fastigata (Valencia type)
- Variety vulgaris (Spanish type).

COMPARATIVE CHARACTERS OF VIRGINIA & SPANISH/VALENCIA:-

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

Characters	Valencia	Spanish
2 ^o – lateral branches	Absent	Present irregularly to 10 – branches
Stem and petiole color	Purple	Green
Hairiness	Less	More
Leaflet color	Dark green	Light green
Inflorescence	Single	Compound
Seeds per pod	usually 3-4	Usually 2
Constriction, reticulation & beak on the pod	Less prominent	More prominent
Shell thickness	Thick	Thin
Testa color	Red to purple	Rose
Maturity	90 – 95 days	100 -105days

VARIETIES

Groundnut var. now under cultivation fall under

Three botanical groups: Spanish, Valencia, Virginia.

Three habitat groups: bunch (Spanish/ Valencia)

Semi spreading (Virginia bunch)

& spreading (Virginia runner)

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

CLIMATE AND SOILS

Climate

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

Rainfall

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

➤ Rainfall should be adequate during flowering and pegging stages.

➤ Ideal RF for successful groundnut crop would be

80 – 120 mm, during summer to facilitate preparatory cultivation

100 – 120 mm, at sowing

200 mm, from flowering to peg penetration

200 mm, early pod development to pod maturity

➤ Rainfall is the most important factor limiting the productivity of rainfed groundnut due to variability in amount and distribution of RF.

➤ Continuous rains leads to excessive vegetative growth resulting in poor pod yield.

➤ Rains at harvest cause germination of kernels in non-dormant Spanish and Valencia cultivars besides problem in pod drying.

Temperature

Soil temperature <18⁰c delays emergence of seedlings. The embryo is killed above 54⁰c.

➤ G.nut performs well in dry temperature range b/n 24⁰c & 33⁰c. but it can survive up to 45⁰c.

➤ Ideal temperature for reproductive stage is b/n 24 – 27⁰c

➤ Rate of pod growth will be maximum b/n 30⁰c & 34⁰c.

Light

➤ Groundnut is day length insensitive plant.

➤ About 60% solar radiation for 60 days after emergence appears to be critical.

➤ Low light intensity

Prior to flowering, slow down the vegetative growth and increases the plant height.

At early flowering, leads to flower abortion.

At pegging , reduces peg and pod number & pod weight.

➤ Flowering phase is more sensitive to reduced light intensities.

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

SOILS

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

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

TILLAGE

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

- Light red soils are usually ploughed twice with the summer rains followed by 2 – 3

Harrowing.

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

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SEASONS:

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

Kharif :- 90% area is under groundnut is during kharif under rainfed conditions.

Average yields are comparatively low due to erratic behaviour of monsoon i.e late onset of monsoon, dryspell during critical crop growth stages, heavy rains at later stages or early withdrawl of monsoon.

Pest & disease incidence is also high in kharif. The climate will be cloudy with lesser sunshine.

- season extend from April to August.

- In black soils, sowings may be delayed even upto

August/September to avoid heavy rains effect on germination.

Rabi :- G.nut cropping during rabi is limited to areas where winter is not severe & temp. do not grow below 15⁰C. It is confined to states of T.N, A.P, Karnataka, Orissa, Maharashtra and Gujarat.

It is grown under irrigated on uplands or with supplemental irrigation in rice fallows.

- Sowing period extend from October to December.

- Second half of November is the ideal sowing time.

Summer :-

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

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

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

SEEDS AND SOWING

Seed selection:-

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

Seed treatment:-

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

Seed treatment with Thiram @ 3g/kg,

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

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

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

Rabi – IGR – 6

Summer – IGR – 40

Granulated Rhizobium strain can also be sown with seed in the furrows.

SEED RATE AND SPACING

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

	Seed rate (kg/ha)		Spacing	
	Bunch type	Semi spreading & spreading	Bunch type	Semi spreading & spreading
Kharif (rainfed)	120	150	30x10 cm	30 x15 cm
Rabi (irrigated)	150	180	22.5 x 10 cm	30 x 10 cm
Summer (irrigated)	150	180	22.5 x 10 cm	30 x 10 cm

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

Method and depth of sowing:

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

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

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

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

NUTRIENT MANAGEMENT

For every tonne of pods & 2t of haulms about 63 N, 11 P₂O₅, 46 K₂O, 27 CaO & 14 MgO kg/ha are removed by the groundnut crop. A balanced fertilizer programme with particular emphasis on P, K, Ca & Mg is essential for opt. yield. Apply 10t well decomposed FYM and incorporate it into soil just before the onset of monsoon.

Nitrogen:-

The necessity for fertilizer nitrogen to groundnut is reduced because of being a leguminous crop, it fixes atmospheric 'N' into the soil with root nodules. Around 200 kg N/ha can be fixed under ideal conditions. Number of cowpea cross inoculation group strains are available as **NC-92 & TAL 1000, THA 205**. In general, 20 kg N/ha – entire dose as basal is recommended for rainfed G.nut 30 Kg N/ha – in 2 equal splits at seeding & 30 DAS – irrigated crop. However the nitrogen fixation process of plant starts working at about 20-30 days after sowing, when the nodule apparatus is fully formed. Till that time to meet the requirement for plant growth, an initial boost as starter dose of 10 kg/ha is necessary for rainfed groundnut. Depending on the number of nodules, another 10 kg/ha at 30 DAS can be top dressed depending on the rainfall. Nitrogen should be preferably applied in the form of Ammonium Sulphate as it also supplies the sulphur.

Phosphorus:-

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

Opt. doses are

Rainfed – 40 kg P₂O₅ /ha irrigated – 50 kg P₂O₅/ha

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

Single super phosphate is the best source as it contains 16% P₂O₅, 19.5% Ca & 12.5% Sulphur along with some traces of Zn & other micronutrients traces. Therefore response to SSP is higher than with DAP at equal nutrient basis. Phosphobacteria as *Pseudomonas striata* and *Bacillus polymixa* solubilises the native phosphorus and recorded 13-20% increase in groundnut yield.

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

Potassium:-

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

□ There is no necessity for potassium application to rainfed groundnut yielding around 1 t/ ha.

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

For rainfed groundnut - 40 kg/ha

For irrigated crop - 50 kg K₂O/ha provided N is applied at recommended rate.

Calcium & sulphur: -

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

□□ Adequate calcium is essential in root and pod zones for yield and quality of kernels. Calcium deficiency leads to unfilled pods called pops and darkening of plumules of embryo.

□□ Sulphur is highly essential as it is directly involved in the biosynthesis of oil. It improves nodulation of Rhizobium and prevents the premature leaf fall & increase the pod & oil yield.

Ca & S are supplied to crop through CaO or gypsum & it has been observed to increase the yield by more than twice depending on its availability in the soil. About 1 meq / 100 g soil in the root zone depth and 3.0 meq/100g soil in pod zone are threshold values for calcium sufficiency. About 100 ppm of heat soluble sulphur is the critical limit of available sulphur for groundnut.

□□ Gypsum application @ 500 kg/ha near pegging zone as top dressing at flowering (30 DAS) appears to be ideal .

□□ If heavy rains occur within 2 weeks after application then a second lighter application of gypsum is necessary around 3 weeks after first application.

K: Ca: Mg ratio :-

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

□□ Increase in conc. of Mg in nutrient solution decrease K uptake by G. nut & also decreases Ca uptake.

□□ There is a mutual antagonistic effect on the uptake of K, Ca & Mg.

□□ The ideal ratio is **4 : 4 : 2**.

Zinc, Boron & Iron:-

ZINC: Zn def. is common on sandy & sandy loam soils. The critical limit of available Zn in soil is <0.6 ppm. Application of ZnSO₄ @ 2 kg /ha once in 2 years corrects the deficiency. If it is observed in standing crop, foliar application of 0.2% ZnSO₄ along with 0.2% lime can correct the deficiency.

BORON: 'B' def. leads to HOLLOW HEART. Deficiency has been reported in light soils of Punjab & T.N. The threshold level of boron is 0.25 ppm. Deficiency can be corrected by soil application of 5–10 kg/ha of boron. In standing crop, corrected by 0.1% borax spray.

IRON: Iron chlorosis is largely due to its reduced availability in the soil. Immobilization of iron in the soil may be due to high levels of lime, high PH (>7.6) or high levels of bicarbonates in soil or irrigation. spraying of ferrous sulphate mixed with 1% of ammonium citrate around 50 DAS corrects iron deficiency.

WEED MANAGEMENT

□□ Weed competition is critical upto 35 DAS.

□□ Yield losses may be to the extent of 70% , especially under rainfed conditions.

□□ When once pegging begins (40 DAS), there should not be any disturbance to pegs through manual or mechanical weeding.

Important weed flora in the groundnut crop are

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

Cultural management:

□□ Hand weeding is done twice, first around 20 DAS & 2nd at about 35 DAS.

□□ Inter cultivation usually starts around 10 days after emergence & continues upto 35 DAS at 7– 10 days interval till pegging begins.

□□ Cost effective weed management under rainfed conditions is , repeated intercultivation (harrowing) upto 35 DAS followed by hand weeding.

Use of herbicide:-

o A mixture of oxadiazon & Dinoseb each @ 1.7 kg /ha gives excellent control of weeds besides reducing stem rot in G.nut.

o Fluazifop (150 – 250 g) is a promising post herbicide for controlling grasses, particularly *cynodon dactylon*, 35 – 40 DAS

o IWM involving the above two appears most effective & economical, provided the crop is not subjected to prolonged drought or soil moisture stress during the crop period.

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

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

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Water management:-

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

Critical stages:-

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

□□Very early growth phase (upto 20 DAS) is least sensitive.

Scheduling of irrigation:-

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

□□Irrigating the crop at

25% DASM – from pegging to early pod development

50% DASM – at other stages appear to be ideal for high WUE without significant reduction in pod yield.

□□An IW/CPE ratio of 1.0 at moisture sensitive stages and 0.6 during other stages leads to high WUE.

□□The water requirement of groundnut, on an average., ranges b/n 450 & 650 mm & WUE is 0.6 to 0.8 kg /m³ (pod yield per unit of water evapotranspired).

□□If irrigation water is not limiting , then a total of 8 irrigations are adequate for optimal yield.

pre –sowing irrigation followed by an irrigation at 25 DAS, 4 irrigations at 10 days interval & final two irrigations at 15 days interval.

□□At times of deficit supplies, an irrigation at 25 DAS followed by 2 at 15 days interval b/n 45

& 75 DAS appears to be minimum requirement & it can minimise yield losses due to soil moisture stress.

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

□□to get the good root system.

□□to reduce excessive vegetative growth.

□□Encourage the better nodulation

□□Induce heavy flowering in a single flush (synchronous flowering)

METHOD:

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

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

CROPPING SYSTEMS:-

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

SEQUENCE CROPPING:-

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

INTERCROPPING:-Imp. Cereal crops grown with g. nut are pearl millet, sorghum & maize. Other long duration crops grown with g. nut as intercrops are pigeonpea, cotton and castor. short duration intercrop with g. nut are sesame, sunflower, cowpea, green gram, black gram.

HARVESTING:-

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

The prominent symptoms of maturity:-

□□Yellowing of leaves .

□□Necrotic spotting on the leaves

□□Dropping of older leaves / leaf fall.

□□The pods become very hard & tough, they give cracking sound when split open with fingers.

□□The inside of the shell turning dark, with netted venation

□□Seed coat develops pink or red colour (normal colour of the varieties)

□□ Raising of the soil to the base of the stem is observed .

Generally harvesting is done by pulling or lifting the plants from the soil with pods intact. If soil moisture is adequate, then hand pulling. If soil is dry, tractor or bullock drawn blades are used for lifting the vines with pods. Harvesting before maturity reduces yield & oil % & seeds are highly susceptible to aflatoxins. If delayed, results in increased incidence of stem rot, weakening of gynophore/peduncle & some of the pods may remain in soil itself at the time of harvesting.

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

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

□□ Drying should be done rapidly to prevent fungal moulding

□□ Sun drying is the usual method of drying.

□□ Summer g. nut should be dried in shade to prevent loss of viability, if it is for seed purpose.

Storage:-

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

□□ Pods for seed purpose are stored for 7 – 8 months.

□□ Pods for seed purpose are stored in earthen pots, mud bins or bamboo baskets or Gunny bags having polythene lining. If the seed moisture content is above the critical level of 9% then Aflatoxin production due to *Aspergillus flavus* just before the post – harvest drying & mould growth at later stage takes place.

Yield Attributes:-

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

Yield:-

Rainfed: - 10 – 15 q/ha

Irrigated: - 20 – 25 q/ha.

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

QUALITY CONSIDERATIONS:-

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

1) Volume weight of pods:-

□□ It is the wt. per unit vol. of pods, which indicates maturity & development of kernels when the pods are disposed by volume.

□□ Small pods have high volume weight than those of bigger pods .

□□ The avg. 100 pod weight varies from 73g (7 MV – 2 , Spanish bunch) to 107 g (M -13- Virginia runner)

□□ Volume weight is influenced by RF distribution at pod development & Ca & S in pod zone.

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

□□ It is the % of kernels to pods by weight.

□□ It ranges from 68% in M13 to 76% in TMV-2.

□□ Irrigated crop has lower shelling % than that of rainfed crop.

□□ It depends on thickness of the shell, development of kernel & following pattern during the

crop period.

☐☐It is influenced by genotype, Rainfall distribution & Ca in pod zone.

3)100 Kernel weight:-

☐☐It is an indication of proper kernel development.

☐☐Average 100 kernel weight ranges from 30 g (TMV 2) to 78 g (in M13).

☐☐It is a varietal character with marginal influence of RF distribution, nutrient management & ability of translocation of photosynthates from source to sink.

4) Oil content :-

☐☐It generally ranges from 48 – 51 %

☐☐It depends on temperature during first 3 weeks of pod development, maturity of kernels which is influenced by RF during development stage & 'S' content in soil root zone.

☐☐Virginia runners have higher oil content than Spanish bunch types.

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

☐☐Oil extracted from runner type have best quality due to higher concentration of TOCOPHEROL.

☐☐The ratio of saturated to unsaturated fatty acid also decide oil quality. The ratio of oleic acid to linoleic acid should be > 1.6 to have long shelf life.

6) Colour of pods and testa of kernel :-

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

Grading :-

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

PODS KERNELS

1) Large/bold 1) Extra large

2) Medium size 2) Large

3) small size 3) Jumbo(shrivelled)

4) Splits(ill filled)

EXPORT POTENTIAL:-

☐☐HPSK & G.nut oil cake are exported to other countries. But in recent years export of these products are drastically reduced due to increase aflatoxin load in the products & increasing domestic demand.

☐☐China is the largest exporter of HPS kernels followed by USA & india.

☐☐The Indian share for the export of Hps is only 2%

☐☐G. nut cake is a good veg. protein & poultry feed. India is exporting large quantity of GN cake in western countries till 1980. Later on the export of G.nut cake was significantly reduced due to higher levels of Aflatoxins.

Lecture 20

Chapter No.10 COTTON (*Gossypium hirsutum*)

Cotton is one of the oldest and the most important commercial crop of the world and forms the most important fibre crop. Cotton textile industry is the oldest Agricultural industry of India. The fibre obtained from seed is used for variety of purpose. But major use of fibre is manufacturing of textiles which provide clothing to the mankind. Ever since the dawn of civilization, cotton served the purpose of providing this need and even today it dominates despite of the production and marketing of many synthetic fibres Cotton is referred to as “ King of Fibres “and also known as “White Gold” Cotton is also used for several other purposes like making threads, for mixing in other fibres and extraction of oil from the cotton seed. Oil content ranges from 15-25 percent. Cotton seed cake after extraction of oil is good organic manure contains 6.4% N, 2.9% P₂O₅ and 2.2% K₂O. Cotton seed and pulp obtained during oil extraction and cotton meal are good concentrated feed for cattle.

Origin and History

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

The cultivated Species are divided into two groups. They are

Old world cotton

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

New World cotton

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

Area and distribution

Cotton is the most important fibre crop of the world cultivated over an area of 34.5 ha with a total production of 54.5 mt. The important cotton growing countries are India, USA, Russia, China, Brazil, Egypt, Pakistan, Turkey, Mexico and Sudan. These ten countries account for nearly 85% of the total production.

Climate

It is a tropical crop and thrives well in hot and humid climate. It is heat loving and sun loving(heliophyte) plant. A daily minimum temperature of 16oC is required for germination and 21 to 27oC for proper vegetative growth. It can tolerate temperature as high as 43oC, but does not do well if the temperature falls below 21oC. During fruiting phase, the day temperature ranging from 27 to 30oC and cool nights are needed. Abundant sunshine during the crop growth period particularly the period of boll maturation and harvesting is essential to obtain a good quality produce. Successfully grown in areas receiving an average annual rainfall ranging from 500mm, of which 175-200mm should be received during crop growth period. If, during the fruiting period heavy showers of rain occur or heavy irrigation is applied, shedding of the flowers and young bolls results. At harvesting also high rainfall is not desirable since it not only affects the quality of lint but also delays

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

Soils: Cotton is a deep rooted crop. As the tap root extends even up to a depth of 200-250cm deep soils are ideal for better root penetration and development. Soils should have good water retention capacity as most of the cotton is confined to rainfed conditions. Soils must be well drained and well aerated since the crop is sensitive to water logging. Crop can tolerate P H of 5.5 to 8.5. The Principle soil types for cotton cultivation in the country are

- a) Alluvial Soils: Punjab, Rajasthan , Haryana, U.P, Bihar, West Bengal, Orissa, Assam, Godavari, Krishna region (A.P)
- b) Black Cotton Soils: Central and Western M.P, parts of M.S, South Orissa, South and Coastal A.P, North Karnataka
- c) Red Soils: Tamilnadu, Karnataka, N-E parts of AP, Parts of MP, Orissa, Assam, UP, West Bengal, Rajasthan
- d) Laterite Soils: Madhya Pradesh, Orissa, Karnataka, E Parts of A.P, Tamil Nadu, Assam, and Kerala.

Land Preparation

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

Seeds and Sowing

Time of Sowing

Time of sowing season of cotton varies considerably from tract to tract and is generally early April – May in N -India and is delayed as one goes down to south. Cotton is essentially grown as Kharif crop in the major parts of the country - Punjab, Haryana, Rajasthan, U.P, M.P, Gujarat, MS and parts of A.P and Karnataka. In these areas Irrigated crop – March to May, Rainfed Crop – June/July. In parts of Gujarat and M.P, pre-monsoon dry sowings are practiced in the end of May or early June to give early stand to the crop.

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

A.P. Northern region – June/July, Central region – Aug/Sept, July/Aug(Hybrids)

Eastern region – July/Aug, Rice fallows – Dec/Jan

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

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

Spacing: Straight varieties – 45 to 60X15cm (R)

-90 to 120X45 to 60 cm (I)

Hybrids -90 to 150X45 to 60 cm

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

Depth of Sowing: 4 to 6cm

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

Seed treatment

The seed of the most of the cotton varieties particularly of American types is covered by short fibre called Fuzz. The fuzz makes the seeds cling together, thus hampering their free passage through the seed hopper and tubes of the seed drill or they are not easily separated for sowing by dibbling. The fuzz also interferes with the

absorption of the water by the seed and delays germination. The H₂SO₄ poured on seed and simultaneously. Wash the seed with fresh water followed by lime water again with fresh water to neutralize the acid residues. The fuzz gets burnt and immediately washed 3-4 times in water and dried under shade. This is called delinting. Delinting can be done mechanically in the cotton gin or chemically or the seed is rubbed with mud or a mixture of earth and fresh cow dung. By this treatment, the fuzz on each individual seed becomes pasted on the seed itself and the seeds no longer cling to each other. In order to control the seed borne diseases the seed is treated with 0.01% Streptomycin Oxytetracyclin (Paushamycin or Agrimycin) and with 0.1% Systemic fungicide like carboxin (vitavax) solutions for 6-8 hours. The treated seed should be dried in shade before sowing.

Gap filling and thinning

To maintain optimum population, gap filling is done with the same stock of seed which was used at the time of sowing. This is done on the 10th day. Wherever seed has not germinated to fill the gaps, the water soaked seeds are dibbled so as to have quick emergence or seedlings are raised in polythene bags at the time of sowing and these are used for gap filling. So that crop growth is uniform. Thinning should be done within 3 WAS, by removing the excess seedlings that are weak, diseased or damaged and retaining robust and strong plants. The main objective is to maintain optimum plant population per unit area.

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Cotton- Zones of India, Classification of Cottons

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

- 1. Northern hirsutum:** – arboreum region: Comprises of Punjab, Western UP, Delhi, Haryana and N.W.Rajasthan. This is most important cotton growing and potential region. More than 90% of the area in this zone is irrigated. Two species of cotton i.e hirsutum and arboreum are grown in this region. At present 60% of the total cotton acreage consists of hirsutum varieties and growing of arboreum has assumed secondary importance. The soils are of alluvial origin.
- 2. Central arboreum region:** This region comprises of many districts of M.P, Maharastra, Gohilwad, Amreli dts of Gujarat and Adilabad dt of A.P. Entire region is characterized by black cotton soils locally called REGAR soils which are highly suitable for cotton cultivation.
- 3. Southern hirsutum – arboreum region:** Comprise the states of Tamilnadu and Kerala. Major soil groups are red soils but also grown on sandy and heavy black soils.
- 4. Central herbaceum – arboreum – hirsutum:** Comprises A.P and Karnataka. The principal soils on which cotton is grown are coastal alluvium, deltaic alluvium, red, black cotton soils, laterite and loamy soils. The major area of cotton is confined to black cotton soils (80%)
- 5. Western – herbaceum region:** Comprises of Gujarat and parts of Bombay and Karnataka. Improved varieties of cotton are grown in this region. Major soil group is black cotton soil followed by loamy soil.
- 6. Eastern region :** Comprises the states of Orissa, West Bengal, Bihar, Assam, Manipur and Tripura. Longest zone with respect to area but the production is negligible from this region.

Classification

The predominant species cultivated
Gossypium hirsutum - >90% of the area
“ arboretum - 5%
Gossypium herbaceum – 2%
Gossypium barbadense – negligible

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

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

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

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

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

Monopodial branches

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

Sympodial branches

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

Manures and Fertilizers

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

	N/ha	P2O5/ha	K2O/ha
Desi Cotton :	20 – 40 kg	20Kg	20 Kg
American Cotton Varieties :	90 Kg	45 Kg	45 Kg
Hybrids :	120 Kg	60 Kg	60 Kg

Entire P205 should be applied as a basal dose at last ploughing and duly incorporated in the soil. Nitrogen and Potassium is applied in three equal splits each at 30, 60 and 90 DAS. While top dressing, fertilizer should be applied in pockets 7 -10 cm away form the plant and at a depth of 7– 10 cm for a rainfed crop. Fertilizer application should be done only in presence of adequate moisture. For the irrigated crop, provide irrigation soon after application of fertilizers.

	N	P2O5	K2O
Rain Fed			
Desi	40	20	20
American	60	30	30
Hybrid	90	45	45

Irrigated

American	120	60	60
Hybrid	150	75	75

Water Management

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

: Flowering stage

: Boll developing stage

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Weed Management

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

Pre –eme Pendimethaline @ 1.5 – 2.0Kg a .i/ha

PPI fluchloralin @ 1.5 Kg a.i /ha

Pre –eme: Alachlor @ 1.5 kg/a.i/ha

Diuron @ 0.8 - 1.0 kg ai /ha

Pronamide @ 1.5 – 2.5kg/a.i/ha

Cinmethiline @ 0.5 -1.5 Kg /ha

Post – eme: Paraquat @ 0.5 Kg a.i/ha or Glyphosate – 3.5 – 4.5 as directed spray on the foliage of weeds

Topping

Cotton is indeterminate plant, to check excessive vegetative growth topping is practiced. Topping refers to the removal of the terminal bud. Level of topping or at what node topping is to be done will differ with cotton plant type.

MCV –5: Topping at 15th node level (70 – 80) DAS resulted in better yields

MCV 7: 10 – 12th node (90DAS)

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

American Cotton – 40 to 60 ppm

Desi cotton - 60 to 80 ppm 50 to 80DAS

Bud and Boll shedding

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

Various reasons for bud and boll shedding in Cotton is

1) Unfavourable Weather conditions:

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

2) Imbalanced nutrient supply

3) Incidence of pest and disease

4) Weeds alter the microclimate

5) Physical injury - due to use of farm machinery

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

Harvesting

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

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

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

3) Kapas should not be contaminated with foreign materials like leaf bits, trash, soil particles etc, at the time of picking and shading. While picking weather conditions must be taken into account. Usually pickings are done in the early hours of the day, As the day advances the fruit wall becomes brittle due to sun and while picking they easily collapse and contaminate. Picking must commence after cessation of dew fall. Cotton of early picking are of superior quality and later pickings produce inferior quality fibre due to inadequate nutrient supply at later stages, high incidence of pest and inadequate moisture at later stages. Boll affected with insect is common feature which not only reduce yield but produce yellow stained cotton which is considered inferior fibre.

Yields

Dryland crop - 10 to 15 q/ha

Irrigated Crops - 25 to 30 q/ha

Hybrids - 35 to 40 q/ha.

1 Bale = 170 kg.

Yield attributes:

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

Lecture 23

Cotton- Quality parameters

1.Colour of fibre

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

2.Length of fibre

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

1. Seed is combed making halo and length is measured by a disc, which gives mean length
2. By measuring each fibre with scale and getting average length which is tedious , laborious and not practicable on large scale.
3. By using digital fibrograph where in sum amount of light is transmitted through the fibre beared after combing along the fibre length and calculated. On the basis of fibre length , cotton is classified into six groups.

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

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

3.Fibre fineness:

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

- 1) Weight /unit length – specified number of fibre are taken with known length and weight is recorded using a sensitive balance.Lesser the weigth, superior is the quality and finer the lint hair.
- 2) By using instrument MICRONAIRE . In this cotton plugs are prepared by using known weigth of cotton lint, i.e. 3-4 gm by pressing in a specially designed cylinder. Air is passed at high pressure through cotton plugs and fineness is determined indirectly by the flow of air through the plug. Finer cotton will allow more air to pass than coarse fibre . This is calculated on a scale and expressed as micronaire value. On basis of fineness, cotton are classified into five groups.

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

4.Fibre strength:

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

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

5.Spinng count:

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

Group	Counts	Vareties
Course Cotton	1 – 17	Maljari
Medium coarse	17-26	AKH4, Sanjay
Superior medium coarse	26 – 35	Nerma
Fine	35 -48	Bur 1007
Superior fine	40- 80	MCU5, H4, H6
	> 80	Varalaxmi, Suvin, DCH 12

6.Fibre maturity :

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

Mature fibres - Yellowish white fibre

Half mature fibres - Bluish or bluish green

Imature fibre - Deep blue or purple

Trash content or Foreign Matters:

Foreign matter mainly consists of debris of leaves and broken stems of cotton and weeds that mix very easily with the lint during harvesting the amount of foreign matter remaining in the lint after ginning depends mainly on the efficiency of the dr ying and cleaning process in the ginning plant. Presence of foreign material will reduce the quality and yarn manufactured from such cotton will have poor strength and gives bad appearance presence of foreign material can be detected and measured quantitatively by instrument called SHERLY ANALYSER

7.Hygroscopicity:

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

Ginning percentage:

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

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

8.Nepiness:

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

9.Lint Index :

It is the weight of lint from 100 seeds

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

10.Seed Index:

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

11.Oil content:

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

Coloured cottons:

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

Lecture 24

Chapter No.11 JUTE (*Corchorus capsularis*)

Introduction

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

OriginJute has two cultivable species

1. *Corchorus capsularis* – originated from Indo-Burma region.
2. *Corchorus olitorius* – Originated from Africa

Wild species of Jute include *Corchorus oestuanus*, *Corchorus tridens*, *Corchorus trilocularis*, *Corchorus urticifolices*, *Corchorus japonicum*.

DIFFERENCES BETWEEN THE TWO CULTIVABLE SPECIES OF JUTE

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

Distribution:

Jute is extensively grown in India, Bangladesh, China, Pakistan, Myanmar, Nepal. In India, it is extensively cultivated in eastern regions like West Bengal, Bihar, Orissa, Assam, Tripura, Meghalaya, Uttar Pradesh. India is the largest producer and consumer of raw jute. Bangladesh is largest exporter of Raw Jute India

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

Properties of Jute:

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

Uses of Jute:

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

Types of Jute:

Based on general utility purposes, Jute is of 4 types

A] Hessian or Burlap:

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

B] Sacking: Also known as “heavy goods” It is made from lower grades of fibre and used for bags of all types

C] Canvas: Finest Jute product, closely woven of the best grades of fibre widely used in India for protection from weather

D] Jute Yarn and Twine: Most of the single strand Jute Yarn produced is consumed by the mills themselves in fabric and twine manufacture.

Varieties:

Varieties of *Corchorus capsularis* – JRC 212, JRC 321, JRC 7447

Varieties of *Corchorus olitorius* – JRO 524, JRO 878, JRO 835

Jute based cropping systems: (Kharif)-(Rabi)-(Summer)

Under rainfed conditions

1. Jute – Wheat
- 2 crops per year
2. Jute – Mustard

Under irrigated conditions

1. Jute – Rice – Wheat
2. Jute – Rice – Potato (followed in West Bengal)
3. Jute – Rice – Cauliflower / Cabbage
4. Jute – Potato – Rice

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Soil:

- Alluvial sandy loams and clay loamy soils are the best suited for Jute cultivation.
- Capsularis Jute can grow even in standing water especially towards the latter part of growth
- Olitorius Jute cannot thrive in standing water and is more drought resistant and hence grown in light soils.
- New grey alluvial soils of good depth, receiving salts from annual floods is best suited for Jute cultivation

Climate:

- Jute is a rainfed crop
- Grows well in warm and humid climate with temperature in the range of 24⁰ C – 37⁰ C with 65-90% relative humidity.
- Jute is mainly grown in Kharif or monsoon season as vegetative growth is more in kharif that results in higher yields of fibre.
- Alternate sunshine hours and rainy days are congenial for better growth.
- Temperatures less than 20⁰C and more than 40⁰C are harmful because it restricts the plant growth especially the plant height.
- Annual rainfall is 80 to 100cm.
- Low plant population is not preferred because of branching and reduces quality of fibre.
- Early sowing of *Corchorus Olitorius* is not preferred because it comes to early flowering, quality is reduced.
- Constant rain or water logging is harmful.

Tillage :

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

Cultivated species of jute	Seed rate (Kg/ha)		Spacing (cm)	No. of Plants Per Sq.mt
	Line Sowing	Broad Casting		
<i>Corchor us olitorius</i>	5	7	25x5	80
<i>Corchorus capsularis</i>	7	10	30x5	67

Time and methods of sowing:

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

Manures and Fertilizers :

5 tons of well decomposed farm yard manure should applied in last ploughing.

Nitrogen should be applied in 2 splits – 1st split as basal and 2nd split at 4-6 weeks after sowing.

Application of Phosphorous reduces the lodging and improves fibre quality .Potassium application prevents disease incidence.

Cultivated species of jute	Nitrogen	Phosphorus	Potassium
<i>Corchorus olitorius</i>	40 Kg /ha	40 Kg /ha	60 Kg /ha
<i>Corchorus capsularis</i>	60 Kg/ha	40 Kg /ha	60 Kg/ha

Weed Management

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

Irrigation:

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

Crop Rotation:

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

Harvesting:

- Duration of *Corchorus olitorius* – 120 to 150 days
Corchorus capsularis – 180 to 200 days
- Early harvesting gives lower fibre yield but fibre is of finer quality, whereas, late harvesting gives higher fibre yield but the fibre is coarse in texture
- Ideal stage of harvest in Jute is 50% of tender pod formation.
- Late harvesting leads to poor quality fibre due to lignifications of bast fibres
- Harvesting is done by cutting the plants close to ground with sickles.
- Harvested plants left standing in the field for 2-3 days for shedding of leaves.
- Afterwards plants are ready for retting.
- Fibre yield is 6-8 years on wet weight basis of stalks.

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Process of Fibre extraction:

Bundle stalks Retting Stripping Washing

Storage / Transport Kutcha packing Boiling Sundry Squeezing excess water

A] Retting

Retting is a microbial process in which bast fibre gets loosened for an easy separation from woody stalks

During retting, gums, pectins and other mucilaginous substances are removed from the plants by combined action of water and microbiological action.

Retting is of 2 types – Dry retting and Wet retting

When water is not available for retting immediately after harvest, plants are allowed to dry, whenever monsoon occurs, dried plants are retted. This process is called Dry retting..

- Harvested plants are immediately retted directly in water without drying and this process is called Wet retting.
- Wet retting is preferable than dry retting because of good quality of fibre.
- After 2-4 days of harvesting, plants are shaken for complete leaf shedding then they are tied into bundles of 25cm diameter.
- Then bundles are steeped in standing water vertically, bundles are submerged in water in a horizontal position laid side by side and tied together to form a sort of platform called “Jak”.
- Jaks are covered with plants like water hyacinth or any other material which do not release tannins as well as iron.
- Float is then kept with weight to make the float completely immersed in water.
- Wood logs and concrete slabs may be used for this purpose
- Freshly cut mango logs or banana stems should not be used weighing material of Jak because tannins coming out from stems reacts with iron of retting water and gives black color to fibre called “Shyamala”.
- This colour can be removed or reduced by adding 2% tamarind solution.
- For ideal retting, JAKS should be kept submerged of at least 20cm deep .
- Most of the defects in fibre quality are due to improper or incomplete or faulty retting.
- Incomplete submergence results in under retting produces a fibre called “crappy fibre” which is of extremely of low value where as over retting results into “dazed fibre” which is very weak fibre.
- So gently flowing fairly deep clean and soft water are congenial for ideal retting.
- Optimum temperature of water should be around 34°C .
- Retting period is 8-30 days.
- In case of stagnating water, addition of Ammonium sulphate will hasten up retting process.
- For finding out exact end point of retting, JAKS must be examined every 10-12 days.
- Fibre should be slip from the wood easily when the plants are pressed between thumb and finger.
- Soon after the end point, JAKS or platforms should be taken out of the water and fibre should be extracted

B] Stripping:

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

C] Washing:

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

D] Fibre is Squeezed for Excess Water

E] Sun Drying:

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

F] Boiling and Packing:

- Extracted fibre is weighed in amounts of bales
 - 1 Bale of Jute =180Kg
 - Jute fibres are pressed based on different grades
 - Jute fibre is graded into
1. Tops – Very Strong Fibre, Good Luster and Colour
 2. Middles – Strong Fibre, Average Luster and Colour

3. Bottom – Sound Fibre, Medium Strength
4. B – Bottom – Sound Fibre, Medium Strength, not suitable for high grades
5. C – Bottom – Medium Strength Fibre, Any Colour
6. X – Bottom – Weak Jute

Yield:

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

Factors hastening up Retting Process:

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

Quality Parameters:

1. Length of Fibre:

- If the length of the entire fibre is more, more is the quality

2. Strength of Fibre:

- Fibre should offer less resistance while using for packing material and other low grade yarn.

3. Colour of the Fibre:

Bright Colour is superior

4. Luster of the Fibre:

- Bright fibre of smooth surface will have superior luster

5. Stiffness and Hardness:

- Properly retted fibre will be soft and fine

6 Fitness of Fibre:

- Coarse fibre always fetches low price than fine fibre

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

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

8 Proportion of faulty materials:

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

Factors influencing Quality of Fibre:

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

Different Institutes working on Jute:

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

Lecture 27

Chapter No.12

Fodder/Forage crops-Importance, classification of fodders – Hay and Silage their preparation and preservation

IMPORTANCE OF FORAGE CROPS :

- Live stock production is an integral part of Indian agriculture.
- India ranks first in live stock 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, 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 live stock production in India which is considered as an important avocation of rural areas in India.

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

Ways to improve fodder production:

To bring more area under fodder crops. In India greater more than 8.8% area under fodder crops should be maintained as per NCA (NATIONAL COMMISSION ON AGRICULTURE)

- Raise short duration fodder crops before or after growing food crop with residual moisture and nutrients.
- Encourage for forage crops(Guinea grass, Stylo and Cenchrus) in horti or silvi-pasture systems.
- Growing more productive crops like NB hybrid and Lucerne
- Forage seed production should be strengthened.
- Growing dual purpose (forage+grain) varieties in crops like sorghum, bajra and oats with strengthening the research on forages in India.

FORAGE RESEARCH AND DEVELOPMENT IN INDIA :

- First research station was established in 1925 Lyalpur in Punjab province.
- National dairy research institute,(NDRI), Karnal, Haryana during the year 1955
- 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.

Terminology in forage production:

Forage crop : A crop of cultivated plants or plant parts other than separated grain produced and grazed or harvested for use as feed for animals.

Fodder : Coarse grasses such as corn and sorghum harvested with seed and leaves green or dry used for feeding as hay, soilage or silage.

Carrying capacity: The maximum stocking rate i.e. animals/ha that will achieve a target level of animal

performance in a specified grazing method that can be applied over a defined period of time without deterioration of the ecosystem. It is not static from season to season.

Agrostology : Study of grasses, their classification management and utilization.

Hay : Fodder conserved in dry form by reducing the moisture content to <15%. This prevents the rapid development of biological processes to build up the heat.

Soilage : Forage cut green and fed to livestock while it is in fresh form.

Silage: Process of preservation or conservation of green fodder under anaerobic conditions in the green form is called Ensiling and conserved fodders called Silage. It is highly palatable slightly laxative and easily digestible.

Haylage : Silage made from the material with high dry matter content under anaerobic conditions. Moisture content is between 40-60%.

Pasture: A grazed plant community usually of several species of diverse botanical types. It includes grasses, shrubs, legumes and trees.

Grassland: Land on which vegetation is dominated by the grasses which are used directly as grazing by the animals or cut and feed systems. Grasses may be either indigenous or introduced grasses.

Rangeland: Land on which the indigenous vegetation is predominant. Grasses, shrubs suitable for grazing or browsing used and are managed as a natural ecosystem.

Paddock: Grazing area which is part of the grass land and separated from the other areas by a fence or barrier.

L : S ratio : Ratio of leaf weight to that of the stem weight. Guinea, Cenchrus, Rodes - 0.5-0.7

N B hybrid- 0.7-0.8

Cowpea, Berseem and Lucerne – 0.9-1.0

Maize, Sorghum, Bajra - 0.5-0.75

Per day productivity: Production of green or dry matter/unit area/unit time. Important parameter for evaluating productivity of forage crops.

Quality Parameters:

Roughage: Animal feeds that are relatively high in crude fibre and low in total digestible nutrients and protein.

Concentrates: The feed is low in fibre and high in total digestible nutrients that supplies primary nutrients (protein, carbohydrate and fat) Eg: cotton seed meal, grains, wheat bran.

Nitrogenous concentrates: Feeds that are rich in protein content. Eg: Groundnut cake, cotton cake.

Non-nitrogenous concentrates: Feeds that have relatively low protein but high in digestible carbohydrates and fats. Eg: Oats and maize grain.

Crude protein: All nitrogenous substances contained in the feedstuffs. It includes true protein, which is composed of amino acids and non protein nitrogenous compounds such as amides.

Crude fibre : All insoluble forms of carbohydrates. It is made up of cellulose, lignin, and hemicelluloses.

$CF = NDF + ADF + ADL$.

NDF: Portion of plant that is insoluble in neutral detergent solution. Synonymous to cell wall constituents.

ADF: Insoluble residue following extraction of herbage with acid detergent solution (Van Soest)

$ADF = \text{Cell wall constituents} - \text{Hemi cellulose}$.

Digestible crude protein: Common way of expressing the protein value digested and taken in to animal body.

$DCP = \text{Feed protein} - \text{Feces protein} (N \times 6.25)$.

High quality protein : A protein containing appropriate portions of amino acids for a particular dietary usage.

TDN: Sum total of the digestibility of the organic components of plant material or seed.

$$\text{TDN} = \text{CP} + \text{NFE} + \text{CF} + \text{Fat.}$$

Proximate analysis: Analytical system of feed stuff that includes the determination of ash, crude fibre, crude protein: either extract, moisture(dry matter) and nitrogen free extract.

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Characteristic Features of Forage/ fodder Crops or ideal characters of forage/fodder crops-

1. It should be succulent and juicy and easy palatable.
2. It should have more number of leaves i.e., high leaf-stem ratio, less shattering of leaves.
3. It should contain high amount of carbohydrates or proteins.
4. Resistance to pests and diseases.
5. It should have regeneration (ratooning) capacity.
6. It should have quick growth and smother weeds.
7. More number of tillers and fine stem.
8. Should be photo insensitive and give more number of cuts.
9. Should have shorter life cycle so that it can fit in cropping systems.
10. It should tolerate shade, drought resistant so best suited for agri, silvi pastoral conditions.
11. Should be suited to different soil classes from III to VII.
12. It should be free from hairs and thorns.
13. It should be free (or) less concentration of anti-nutritional factors.

Classification of fodder crops

I. BASED ON FAMILY:

- a. Poaceae: Wheat,maize,jowar and bajra.
- b. Legumaneae: Cowpea,Lucerne.
- c. Cruciferae: Chinese cabbage,Japanese rape.

II. BASED ON MAINTAINANCE

- a. Maintainance crops : Ex :Maize,Bajra,Sorghum
- b.Non-maintainance crops: Ex :Wheat Bhusa, Rice Straw, Sorghm & Maize stover.

III. BASED ON THE PROTEIN CONTENT:

- a. Low protein forage crops: Ex:Cereals,grasses
- b. High Protein forage crops: Ex:Legumes

IV. BASED ON SEASON :

Kharif	Rabi	Summer
Cowpea	Oat	Bajra
Sorghum	Barley	Multicut sorghum
Maize	Berseem	Cowpea
Grasses	Lucerne	Grasses

V. BASED ON ORIGIN

a.Indigenous sps.

Ex : Marvel grass,Anjan grass

b.Non-Indigenous sps.

Ex :Signal grass,Timoty grass

VI. BASED ON LIFE CYC LE

1) Annual or Seasonal

- i) Legumes. Ex: cowpea, Berseem (D)
- ii) Non-legumes or cereals. Ex: maize, sorghum A & B

2) Perennial forage crops :

- i) Non-legumes or grasses : Ex : Guinea grass (C).
- ii) Legumes. Ex: Subabul, Lucerne (E) & F

VII. BASED ON HABIT:

- a. **Herbs:** Cylinder stem goes vertically but <2m length. Ex: Cowpea, Jowar, oat, maize.
- b. **Shrubs:** Bushy in nature and may be biennial or perennial. Ex: Hedge Lucerne, guinea, hybrid napier.
- c. **Trees:** Trees are pruned to feed the cattle with twigs along the leaves. This practice is called lopping. Useful in lean months. Ex: Subabul, Sesbania.

VIII. BASED ON HABITAT:

- a. **Cultivated fodders:** Productive fodders which give higher green fodder yield (GFY). Ex: NB Hybrid, Lucerne.
- b. **Wasteland fodders:** Less productive fodders. Give less GFY and grown under poor management conditions. Ex: Rhodes grass, Marvel grass.
- c. **Marshy land fodders:** Forages grown under waterlogged conditions. Ex: Paragrass.
- d. **Aquatic fodders:** Forages grown under standing water. Ex: Water hyacinth and algae.

Annual or Seasonal Non-legumes (A)	
1. Maize or corn	<i>Zea mays</i>
2. Jowar or sorghum	<i>Sorghum bicolor</i>
3. Pearl millet	<i>Penisetum americanum</i>
4. Finger millet or Ragi	<i>Eleusine coracana</i>
5. Teosinte	<i>Euchlaena mexicana</i>
6. Foxtail millet or korra or Italian millet	<i>Setaria italica</i>
7. Proso millet or variga	<i>Panicum milliaceum</i>
8. Little millet or sama	<i>Panicum miliare</i>

Winter or Rabi cereals (B)	
1. Oats	<i>Avena sativa</i>
2. Barly	<i>Hordeum vulgare</i>

Perennial Non-legumes (C)	
1. Hybrid Bajra Napier	<i>P.americanum x P.purpureum</i>
2. Guinea grass	<i>Panicum maximum</i>
3. Para grass	<i>Brachiaria mutica</i>
4. Anjan grass or Buffel grass	<i>Cenchrus ciliaris</i>
5. Anjan grass or Buffel grass	<i>Cenchrus setigerus</i>
6. Rhodes grass	<i>Chloris gayana</i>
7. Dinanath grass	<i>Pennisetum pedicellatum</i>
8. Napier grass	<i>Pennisetum purpureum</i>
9. Rye grass	<i>Lolium perenne</i>

Annual or Seasonal legumes (D)	
1.Cowpea	<i>Vigna anguiculata</i>
2.Field bean or Lab lab	<i>Dolichos lablab</i>
3.Cluster bean(Guar)	<i>Cyamopsis tetragonoloba</i>
4.Sunhemp	<i>Crotalaria juncea</i>
5.Pillipesara	<i>Phaseolus trilobus</i>
6.Berseem	<i>Trifolium alexandrium</i>
7.Horse gram	<i>Macrotyloma uniflorum</i>

Perennial Legumes (E)	
1.Lucerne	<i>Medicago sativa</i>
2.Stylo	<i>Stylosanthes hammata, Stylosanthes scabra</i>
3.Siratro	<i>Macroptilium atropurpureum</i>
4.Hedge Lucerne	<i>Desmanthes virgatus</i>
5.Perennial groundnut	<i>Arachis glabrata</i>

Tree species (F)	
1.Subabul	<i>Lucaena leucocephala</i>
2.Khejri	<i>Prosopis cineraria</i>

Other fodders (G)	
1.Chinese cabbage	<i>Brassica pekinensis</i>
2.Grain Amaranthus	<i>Amaranthus viridis</i>
3.sesbania or shevri	<i>Sesbania sesban</i>
4.Sesbania or agate	<i>Sesbania grandiflora</i>
5.Hariyali/Bermuda/Star grass	<i>Cynodon dactylon</i>
6.Spear grass	<i>Heteropogan contortus</i>
7.Blue panic grass/giant panic grass	<i>Panicum antidotale</i>
8.Marvel grass	<i>Dichanthimum annulatum</i>
9.Clitoria/Sangu pushpam	<i>Clitoria cernatea</i>
10.Centro or Butterfly pea	<i>Centrosema pubescens</i>

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SORGHUM (*Sorghum bicolor*)

Common name Sorghum/jowar/Milo/Guinea corn

Plant Characters and uses :

1. Better regeneration capacity. Produces several thin & succulent tillers with more no. of juicy & succulent leaves which make it more palatable than grain sorghum.
2. Supply fodder for long time due to its multi cut nature.
3. Rapid growth of plants and tolerate to shoot fly & leaf spot diseases.

CP: 7-7.75% (Crude protein)

DCP: 3.3 - 4.25% (Digest able crude proteins)

TDN: 64%-single cut varieties (Total Digestible Nutrients) 53%-multi cut varieties

Origin, and Distribution

Sorghum is one of the most important food cum fodder crop grown mostly under dry land conditions and as irrigated fodder in many milk shed areas. Sorghum is believed to be indigenous to **Africa** although India and China have been claimed to be the home of at least certain varieties of sorghum. The term Sorghum is derived from Italian word Sorgo which means rising above to denote its tallness as compared to other cereal crops. It is grown extensively in low rainfall areas of America, Manchuria and Australia. In India grown mainly in states of Madhya Pradesh, Maharashtra, Gujarat, Andhra Pradesh, Uttar Pradesh.

Climate & Soils:

Sorghum is almost unique in its ability to grow over a wide range of climatic and soil conditions, particularly in climates too hot and too dry than other cereals. Being well adapted to arid and semi arid conditions. Sorghum is a crop that thrives in tropical climate with optimum temperature range of 25°-35° c. It is not suited to elevated high elevations of 1220 m and above. Being more often a rainfed crop comes up well when rainfall is about 300-450 mm. It can be grown in all types of soils. Sandy loam to clay loam soils are best suited. Optimum pH is 5.5-8.0.

Land preparation: Plough the field once with iron plough and twice or more with the country plough to obtain good tilth. Form ridges and furrows 6m long and 50cm apart or beds of 5x 4m depending on the availability of water and slope of the land. Form irrigation channels suitably.

Varieties:

Single cut: HC 136, HC 308, HC 260, PC 5, P C 6, PC 9, MP chari, UP chari, UP chari-2, APFS 5-3.

Multi cut: CO27, COFS 29(>5 cuts), SSG59-3, SSG-988, MFSH -3, Harasona, Proagro chari, Safed moti (FSH-92079), Punjab sudex.

Dual purpose : SSV-84, CSV -15, CSH-13, AJ-140, N-14, N-13. SSG 59-3: Cross between *Sorghum bicolor* x *S.sudanense*.

Season:

Under irrigation sorghum can be grown in all months of the year, although in actual practice it is mainly grown in two seasons, December –January and March – April. As a fodder crop it is convenient to grow it in staggered sowing in different months for cutting and feeding. Usually sown from June till August as south west monsoon crop.

Seeds & Sowing

The seed rate for irrigated crop is 40 kg/ha in rainfed areas 75 kg/ha. In the south of Madras a very high seed rate 90-112 kg/ha is used to secure a fine and thin stalked fodder

Spacing & Sowing: 30 X 10 cm. Plant to a depth of 3-4 cm on the sides of ridge or use a seed drill or sow behind the seed drill and cover with harrow or country plough. Seed Treatment with Azospirillum (3 packets 600g should be practiced).

Manures and Fertilizers: In regions of low rainfall, sorghum should be manured with 25t/ha FYM or compost and covered by means of blade harrow. Sheep penning and carting tank silt is also prevalent in some areas of peninsular India. The recommended nitrogen (30kg/ha), phosphorus (40kg/ha) and potassium (20kg/ha). With band application of fertilizer mixture prior to the sowing is preferred. 1/3 N total P&K as basal, 1/3 N at 25&50DAS. 40 kg N/ha after each cut in multi-cut type varieties should be adopted.

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Chapter No.13 Cowpea (*Vigna Unguiculata*)

Common name : Cherry bean/ Blackeye pea/barbati/Southern pea

Plant characters and uses:

- Annual /perennial bushy climbing herb.
- Trifoliolate leaves with fast and quick growth.
- It is tolerant to shade.
- Roots penetrate to 55 cm
- Readily accepted by animals at all stages of crop growth.
- Protein content is 16-18%

Origin, and Distribution : Cowpea is considered as native to central africa, though it is claimed to be indigenous to india as well. It is has been cultivated from very early times for human consumption in the Mediterranean region by the greeks, romans and spaniards.

Climate & soil:

Cowpea can be grown in all tropical, subtropical and temperate regions between 30° N-S and on wide range of soils, but Sandy loam soil with pH 5-6.5 are the best for this crop. Saline, alkaline and water logged soils not suitable. Heavy clay soils encourage vegetative growth with less seed production. It can withstand moderate drought and heavy rains. It can also grow under the shade of tall trees, but cannot survive cold or frost. In fact no other legume can grow so well under such a variety of soil and climatic conditions , with so little attention, as cowpea.

Land preparation:

Plough the field once with iron plough and twice or more with the country plough to obtain good tilth. Form ridges and furrows 6m long and 30cm apart of beds of 5x 4m depending on the availability of water and slope of the land. Form irrigation channels suitably.

Varieties:

Russian giant, (EC-4216), IGFRI 450, IGFRI 985, IGFRI-8503 CO-5, CO-8, UPC 5286, UPC-287 and HFC-42-1,S-450,S -457, FOS-1, Bundel lobia-1 &2, Shewta 988,GFC-1&2.

Season:

Under irrigated condition throughout the year it can be cultivated June - July is preferred or the onset of spring. In rainfed areas October – November months are suitable: January – February. Months or suitable for

summer sowing Cowpea is not so season bound as some other pulses and so it can be grown in any months of the year, except some hottest summer months.

Seeds & sowing:

Seed rate: Under irrigated conditions 20-25 kg/ha; for rainfed areas 40kg/ha in south and 45 to 55 kg/ha in north. Spacing is 30 x10 cm.

Seed treatment: Treat the seed with 3 packets of rhizobium using the starch binder. Sowing: sow to a depth of 3cm on one side of the ridge or sow above the fertilizer band at 2cm depth and cover with soil.

Manures Fertilizers:

Apply 10 t/ha of FYM or compost after the second ploughing. The recommended nitrogen- applied 25kg/ha, phosphorus-40kg/ha and potassium 20kg/ha. Fertilizer mixture should be applied prior to the sowing. 1/2 N, total P&K as basal, 1/2 N at 25 DAS.

Irrigation:

Irrigate immediately after sowing and give light irrigation on the 3rd and thereafter can be irrigated at 10-15 days interval depending upon the climate for soil, moisture status.

Weeding: Cowpea is having smothering effect. Hence weeding may not be economical . If weed problem is there, one hand weeding 20 DAS. With soil mulch is sufficient to eliminate existing the emerging weeds..

Plant protection:

If sucking pests are noticed spray methyl demeton 25EC 500ml or dimethoate 30EC 500ml or phosphomidon 85WSC 250ml/ha in 250 litres.of water. stop spraying 15-20 days before harvest..

Harvesting:

As a fodder crop, cowpea can be cut in 60-75 DAS or at 50% flowering to formation of pods.

Yield: 20-30 t/ha under irrigated conditions and about half this quantity under rainfed conditions can be obtained.

Cropping systems:

Inter cropping at1:1 ratio with maize, jowar or bajra or 2:1 with grasses or creal fodder crops will help to improve fodder yield as well as fodder quality. Cowpea-sorghum+cowpea-berseem.

Lecture 31

Chapter No.14 CLUSTER BEAN (GUAR) (*Cyamopsis tetragonoloba* L.)

Guar or clusterbean ,among leguminous crops is comparatively more drought hardy crop . It is generally grown for feed , fodder and vegetable purposes . Among dryland crops , guar occupies an important place in the national economy because of its industrial importance mainly due to the presence of gum in the endosperm . guar gum is highly mucilaginous , which is being used in various industries such as textiles , cosmetics , explosives, paper,food processing . The fodder of guar as well as its grain are quite nutritive , rich in protein,fat and minerals. It can also be used as a green manure crop in certain areas. Guar provides edible pods which are used as vegetables.

ORIGIN - Tropical Africa

CLASSIFICATION Genus *Cyamopsis* is an old world genus belonging to the tribe Galegeae of Papilionaceae. There are four major species :

- (1) *C . tetragonoloba*
- (2) *C . senegalensis*
- (3) *C . serrata*
- (4) *C . dentata*

BOTANICAL DESCRIPTION

Cluster bean belongs to the family Leguminosae . its plant is robust, erect annual which is usually grows to a height of 90 to 180 cm . certain varieties may grow even taller than this . its plant has a well developed tap root system. The leaves are trifoliolate and toothed. The flowers are borne in short axillary racemes and are generally purplish in colour.

CLIMATE REQUIREMENTS

Cluster bean is a drought resistant crop and can be grown successfully in areas where average annual rainfall is 30-40 cm. Proper germination of seeds and root development takes place between 20 to 30°C temp. It cannot stand waterlogging condition.

SOIL

Cluster bean can be grown on all types of soil except heavy and poorly drained soils. It thrives best on well drained medium to light soils with pH range of 7.0 -8.5 .

VARIETIES

Durgapur Safed , FS-277,Ageta Guara, HFG-119,HFG-156,Guara-80,Bundle Guar-1,Bundle Guar-2,D-111,D-128,AGFRI-212-9,AGFRI-2365-2

CROPPING SYSTEMS

1. Pearl millet + guar-berseem(Egyptian Clover)
2. Sorghum + guar-berseem-maize+cowpea
3. Guar-berseem-maize+cowpea

SEED RATE AND SPACING

15 to 20 kg per hectare is sufficient for grain crop. A combination of 45cm row to row and 15 to 20 cm plant to plant is best for normal sown grain crop. In late sown crop row spacing is 30 cm instead of 45 cm.

MANURES AND FERTILIZERS

20kg nitrogen should be used as starter dose at the time of planting. It is desirable to apply 40-60 kg P₂O₅ per ha to ensure good yields. 10-20 tonnes of FYM is added before sowing.

WATER MANAGEMENT

The crop sown in July does not require any irrigation if the rains are normal and timely; otherwise one or two irrigations may be needed. For a summer crop, irrigation should be given at 12-15 days intervals.

WEED CONTROL

Fluchlorolin (Basalin) can be used at the rate of 1 kg a.i. per hectare. It should be used as pre-planting dose and incorporated well up to 10 cm of soil prior to sowing. It controls annual grasses as well as broad leaved weeds.

DISEASES

Bacterial Blight -control measure

- (1) Seed treatment with hot water at 56°C for 10 mins controls the disease.
- (2) Grow resistant varieties.

Alternaria Leaf Spot -control measure

- (1) spray 0.2% MANCOZEB 75 WP at the interval of 15 days twice or thrice.

HARVESTING

When the crop is grown for fodder purpose the plants are cut when in flower or when the pods are beginning to form (50-85 DAS). When grown for seeds the crop is left until the plants are mature. Crop is harvested with the help of sickles and then dried and threshed.

YIELD

A good crop of cluster bean (guar) yields about 250-300 quintals of green fodder or 10-15 quintals of grain per ha.

Lecture 32

Chapter No.15 NAPIER

Common Name : Giant Napier /Pusa gaint napier / Gajraj / Giant Elephant grass

Plant Characters & Uses :

- 1) More vigorous, nutritious, succulent and palatable than napier grass.
- 2) It is a triploid and hence sterile.
- 3) Highly responsive to fertilization.
- 4) It is tall growing (200-300 cm), erect, stout, deep-rooted perennial grass.
- 5) Lodging resistant and resistant against pests and diseases.
- 6) **Crude protein:** 9-11% **DCP :** 5.5% **TDN :** 58%

Origin and Distribution A Cross between Bajra X Napier grass

P. americanum x P. purpureum was developed in South Africa with the name “Babala Napier hybrid” or Bana grass. It produced more number of tillers and leaves, grew faster and yielded more fodder than the napier grass, but the stem of the hybrid was hard it comes up well in all tropical and sub tropical areas of high rainfall in the world. It is important component of orders in intensity dairying for continues supply of fodder year round.

Climate & soil:

It is cultivated in areas receiving more than >1000 mm rainfall.

It can withstand drought and recover the growth quickly with the onset of monsoons.

Optimum temperature is around 24-28°C.

It can tolerate low air temperatures but less than 10°C makes the crop remain dormant.

It is sensitive to frost. Even a light frost kills the crop but the underground rhizomes will sprout again when the temperature rises.

It performs better under long day than short day photoperiods.

Soil: Sandy loam or clay loams are the best.

pH range : 6.5 – 8.0. In sandy soils, its vigour is low and yield is reduced.

- It cannot withstand flooded or water stagnated condition.
- It should be grown in well-drained soils with good moisture retention capacity.
- It comes up well in saline sodic soils better than guinea grass.

Land preparation: It needs thorough land preparation plough the field 4-6 times followed by harrowing. Then made into ridges and furrows.

Varieties:

In India, first hybrid developed is NB-21.

CO 1: It is profusely tillering, highly leafy, tall growing and non-lodging, yields 300 t/ha. Released during 1982.

CO 3: Released during 1996. It is tall growing, highly tillering and non-lodging with low oxalic acid and crude fibre content. Yield 300-350 t/ha.

APBN 1: Released during 1998 by AICRP on Forage Crops, L.R.S., ANGRAU. It is tall growing highly tillering, more leafyness (high L:S ratio) with low oxalic acid content. It is found to be drought resistant and adopted for cultivation.

Other varieties:

Pusa giant – For cultivating all over India PBN – 83 – Punjab

Yeshwant (RBN-9) – Maharashtra

K K M-1 – Tamilnadu

IGFRI No: 3: It is a profusely tillering type with erect growth habit. It is good for intercropping and has the capacity to yield 100-150 t /ha green fodder per year. It is suitable for NE hills, U.P., M.P. hills of N. India.

IGFRI No: 7: Suitable for temperate zone of the country. It is an erect growing and leafy variety with high regenerative capacity. 120-150 t/ha. It may be grown under acidic conditions.

IGFRI No: 10: It can be grown throughout the country. It is also erect growing, leafy and multicut variety. It produces 100-160 t/ha green fodders per year. The variety is also suitable for acidic soils and sub-temperate situations.

Season: It can be grown during any part of the year provided sufficient water is provided. Optimum time of planting during Kharif and summer is June and February respectively winter sowing is not recommended due to low temperatures.

Seeds & sowing:

Seed rate : 40,000 rooted slips or stem cuttings/ha. Spacing is 50 x 50 cm. Irrigate the field through furrows and plant the one rooted slip or stem cutting per hole at a depth of 3-5 cm on one side of the ridge

Method of sowing : The seed of hybrid napier is sterile. Therefore hybrid bajra napier is multiplied only through stem cuttings or rooted slips. The stem cuttings are obtained from clumps grown up to 2.5 to 2 m ht. Top ¼ is removed and remaining ¾ is used. Rooted slips are obtained from clumps, which are 1 m width.

Stem cuttings: Stem cuttings can be stored for about 20 days for planting by covering with moist gunny bag but in sub tropics, with cold weather, they can be stored during the entire winter season.

45° angle method: Stem cuttings are obtained from basal ¾ portion of the plant. Each stem cutting with 2 nodes measures about 30-40 cm inserted in the soil in a slanting position at 45° angle. One bud should be inside the soil and one bud should be exposed over the soil surface. Buds inside the soil develop roots and, the bud over the soil produce shoots.

End to End Method: 2 budded or 3 budded setts are placed in the furrow such that eyes on the node are exposed to the sides of the furrows and then cover with soil. Then irrigation is given.

Rooted slips: Break up the old clumps and separate the tillers along with their roots. Each slip should consist of 1-2 tillers measuring 10-12 cm height. Dig a small hole in the furrow and insert the roots into these holes. Propagation by this method is best in Summer Season. The stem cuttings are likely to dry up due to desiccating winds and hot summer.

Manuring:

Being the heavy feeder this hybrid should be manured with 25t/ha FYM or compost. 50kg/ha of

nitrogen, 50kg/ha of phosphorus and 40kg/ha of potassium. Band application of the fertilizer mixture prior to the planting is preferred. For this open furrows 5cm deep on the one side of the ridge, apply fertilizer mixture and cover with soil. Repeat the basal application once in year for the sustained higher yields. Top dress with 100 kgN/ha after each cut.

Irrigation:

Irrigate immediately after sowing and give light irrigation on the 3rd and thereafter can be irrigated at 10-15 days interval depending upon the requirements of crop.

Weeding and inter cultural operations:

Hand weeding or hoeing and weeding should be followed on the 30th day. Gap fill to maintain population. Subsequent weeding may be carried out preferably after each harvest. Earth up once after three cuts and removal of dried tillers and quartering once in a year is recommended.

Harvesting :

When cutting the crop for forage, a fairly long stubble of 13-15cm has to be left, to avoid damaging the growing point near the base of the plant . first cut at 60-75 days after planting and subsequent cuts once in 45 days. In case of sewage or high N containing effluents irrigation, the harvest interval may be increased to 55-60 days to minimize the nitrate/oxalate problem.

Yield: Green fodder yield is about 350t/ha/year

Major cropping systems:

Intercropping/mixed cropping with Desmanthus at 3:1 ratio will help to improve fodder quality and yield of green fodder. The other compatible mixtures include Lucerne.

N-B hybrids+velvetbean-berseem_sarson.