Lecuture No: 1

R I C E (Oryza sativa)

TRADITIONAL VARIETIES & THEIR YIELD POTENTIAL-CONCEPT OF NEW PLANT TYPES (NPT's)

Reasons for low yield of crops-

1. Poor genetic yield potential of varieties of different crops.
2. Under identical conditions genetic makeup of a variety is most significant factor in determining yield.

In recent years due to all round efforts of agricultural scientists it has been possible to cultivate HYVs of cereal crops which are often been termed as **"NEW PLANT TYPES".**

1. **IDEOTYPE :** refers to plant type in which morphological and physiological characteristics are ideally suited to achieve high production potential and yield reliability.

2. NPT's are also called as **fertilizer responsive** varieties since these NPTs possess the trait of high responsiveness towards heavy fertilizer applications.
3. NPT's are also termed as adaptable varieties means the physiological attributes of variety responsible for

a) Controlling the assimilation of absorbed N in plant body.
b) Translocation and storage of photosynthetic products.
c) Possessing more activity of roots under heavy application of fertilizers.
d) Availability of resistance to lodging and diseases.

But, the term NPT seems to be more appropriate and reasonable as it can very easily express the extent of improvement incorporated over the old type varieties.

The so called improved tall varieties cultivated by farmers generally grow very tall and possess low yielding potentiality due to

1. Weak and tall straw, susceptible to lodging under heavy fertilizer application.
2. Inefficient leaf arrangement responsible for poor photosynthetic activity and less utilization of Solar energy.
3. Many associated attributes like unsynchronized susceptibility towards the attack of pests and diseases.

NPT's do not posses these defects and have been further improved to increase their production efficiency where the morphological frame work has been genetically linked with other yield contributing characters. Recent developments in plant breeding made significant contribution towards concept of NPTs. The successful efforts of altering the morphological architecture of crop plants and making them suitable for cultivation under high fertility status of soils have opened a new VISTA in developing the varieties suitable for good agronomy.

CHARACTERS OF NPT's : They should be

1. Morphologically be dwarf in growth habit with hard and stiff straw.
2. Erect and dark green leaves remaining active for longer duration.
3. Agronomically highly responsive to heavy fertilizer application
4. Physiologically be well equipped for more dry matter production and high yields.
5. Adaptable under different agro climatic conditions and of short growing duration.

Ex : NPT's made in wheat, rice, jowar, bajra and maize.

Important features of such NPT's of cereals in grain crops are :

1. DWARFNESS :

NPT's are dwarf in nature due to **NORIN** in wheat and **DEE-GEE-WOO-GEN** in rice dwarf genes. NPT's are short, stiff, not more than knee high but could take more fertilizers without lodging.

2. EFFICIANT LEAF ARRANGEMENT :

NPTs are narrow, thick, erect and dark green color with optimum LAI composed of properly arranged leaves, which remain active for longer period after flowering due to high sunlight interception they play important role in supporting grain formation resulting into more number of fertile grains per ear head.

3. SYNCHRONOUS TILLERING :

The growth and development of NPTs are more or less rhythmic i.e., high germination %, formation of all tillers at a time (during a specific period) and timely maturity of all the tillers. So, they have highest synchronized coefficient as regards to the development and maturity of grains of different ears of a plant.

Synchronization of tillering has been found to be dependent on other factors like moisture, proper secondary regrowth and adequate nutrient availability during the period.

4. LOW FLORET STERILITY :

Traditional tall varieties under heavy fertilizer application produce more sterile florets. NPT's have a very low floret sterility % due to synchronized tillering into uniform ear head formation supported by longer physiological activity if leaves at naturity. Low floret sterility an in NPT's has also been attributed due to increased activities of roots at grain formation stage.

5. SHORTER GROWTH DURATION :

NPT's have shorter duration than tall varieties. The optimum growth duration of a variety is more important for scheduling its irrigation and manuring for obtaining higher yield. At High N application longer growth duration and at low N application, short duration variety is preferred for obtaining higher dry matter production as well as more grain production efficiency i.e., grain yield/unit area/unit time. These short duration varieties can fit very well in under high cropping intensity programmes like multiple and relay cropping.

6. ADAPTABILITY TO DIFFERENT CROP SEASONS :

All most all NPT's are photo insensitive and completely resistant to fluctuations in day length. They can be grown under all crop seasons provided inputs like fertilizers and irrigations are adequately made available, so higher yields can be obtained. However, some of the NPTs are thermo-sensitive and are affected by variation in temperature during season.

7. ABSENCE OF SEED DORMANCY :

NPTs have no dormancy i.e. they do not require any rest period, called dormancy period. Freshly harvested seed can be used for sowing. This character is useful in seed multiplication programmes of HYVs, within a short span of time. This along with photo insensitivity makes them quite suitable for adaptation under high intensity cropping programmes.

8. EFFECTIVE TRANSLOCATION OF FOOD MATERIAL FROM PLANTS TO GRAIN :

NPTs have higher potentiality to absorb and assimilate nutrient from soil throughout the growth duration which in combination with higher photosynthetic activities enable them for higher dry matter production. The built in efficient plant mechanism in NPT's coupled with fewer organs respiring at flowering stage permit more efficient use of respiration for growth and grain production. After flowering, this enables effective translocation of accumulated food materials of straw for grain formation.

9. RESPONSIVE TO HEAVY FERTILISER APPLICATIONS :

NPT's possess the trait of high responsiveness towards fertilizer application. Their optimum N requirement is 2 ½ -3 times more than the requirement is so called improved local varieties similiarly the P&K requirement of NPT's are also 1 ½ -2 times more in comparison to local types. Under low fertility status, their yielding ability is not fully utilized and very often they give quiet poor yield under sub optimum conditions, it is therefore necessary to supply adequate quantities of N, P&K in order to exploit their high yielding potentiality to the maximum. Research results (**AICRP)** revealed that on an average, NPT's require about 100-120 kg N, 50-70 kg P? O5 and 40-60 kg K2O/ha under optimum conditions of soil moisture status.

10. LODGINIG RESISTANCE :

NPT's are generally dwarf in growth habit with strong and stiff stem which provides them considerable resistance against plant lodging. Under heavy fertilizer applications, the tall varieties are bound to lodge resulting in substantial decrease in yield. Contray to this, dwarf HY NPT's seldom lodge unless too heavy fertilizer application has been made coinciding with excessive water application. Because of incorporation of dwarfing genes in NPT's, they possess the trait of high responsiveness towards heavy fertilizer application without lodging.

11. YIELDING POTENTIALITY :

The NPT's are known for their HY potential. NPT's are capable of yielding 2-3 times more grain yield in comparison to local tall improved types. This is probably due to their altered morphology which results into efficient utilization of water, nutrients and radiation and increased metabolic activities with high dry matter production. Their grain to straw ratio is approximately about1:1. However, these strains are more susceptible to any degree of variation in manageable inputs. Inadequate and untimely supply of nutrients, irrigation and plant protection measures may result into partial or complete failure of crop.

12. DISEASE SUSCEPTIBILITY :

The only drawback associated with NPT's is the disease susceptibility with luxuriant vegetative growth; the varieties offer scope for insect pests and diseases. However, attempts are being made to develop disease resistant NPT's.

Eg : Rice ------- BPH resistant varieties ----- MTU-2067, MTU-2077 and MTU-4870.

Gall midge " ------ Pothana, Kakatiya, Phalguna.

Wheat ----- Rust resistant varieties ----- Sonalika.

Sorghum ---Striga resistant varieties -----N-13, SPV-462.

Lecture No: 2

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.

Cereals ? The crop plants which belong to the family graminae and are grown for their edible starchy grains/seed called caeryopsis (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'.

In India, rice is grown is 42.7 m.ha constituting 30% of net cultivated area of 142.2 m.ha(1990-91) of this 93% is being cultivated during kharif season.

East and central India accounts for 70% of rice area.

Among the states of India, AP is the maximum rice producer with 106.35 lakh tons (enjoying 3rd rank), the first and second being WB and UP respectively. The Productivity of rice in AP was 2407 kg/ha in 1992-93 against the Inidia's productivity of 1742 kg/ha.

In AP, rice is grown in an area of 40.14 lakhs ha a production of 106.35 lakhs tons and productivity of 2495 kg/ha during 1999-2000.

The area is roughly 3 times more in kharif than in rabi.

Within the districts of AP, West Godavari ranks first both in production followed by Krishna district. (The area is also more in W.G district followed by Krishna district). Productivity is more in Guntur (3005 kg/ha) followed by West Godavari district (2994 kg/ha)

Area, Production and Productivity of Rice

In diff. Zones of AP(1990-91)

	Area 000 ha	Production 000 t	Yield (kg/ha)
KG Zone	1646	4131	2665
NC Zone	467	828	1846
Southern Zone	384	1004	2736
NTZ	953	2276	2251
STZ	460	1118	2369
Scarce RF Zone	126	297	2362
	4033	9654	

ORIGIN : Rice is one of the oldest cultivated crops in China & India for several thousands years. Cultivated species Oryza sativa is thought to have originated in South & SE tropical Asia. Other species of rice are O.glaberrima, O.perennis. In Oryza sativa, the somatic chromosomal no is 2n=24 which corresponds to that of many wild species of Oryza. Some wild species of Oryza are tetraploid, 2n = 48. Rice has been cultivated for thousands of years under widely differenst geographic and agroclimatic regions. During this long period different forms and varieties have been evolved.

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

(i) 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 requiremet is from Panicle Initiation to until about 10 days before maturity which is important for the accumulation of drymatter. 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

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.

	Growth Stage	*cardinal temp (oc)*		
		Low	*High*	*Medium*
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	PI	15	-	-
7	Initial flowering	15-20	30	18-28
8	Anthesis	22	35-36	30-33
9	Ripening	12-18	30	20-29

Night temperature of 15-20^{o} C is favourable. Higher mean temperature will reduce the growth duration.

3. Day Lengh : 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.

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 1240 mm.

Rice crop is being cultivated under widely varying climatic conditions as detailed below:

Latitude	:	45^o N – 40^oS
Altitude	:	Mean Sea Level to 1524 m
RH	:	35 – 100%
Rainfall	:	20” – 200” (500mm to 5000mm)
Temperature	:	20^o -35^o C
Daylength	:	9 hrs. optimum
Light	:	400 cal/cm^2/day is the minimum requirement.

Growth States of Rice Plant

Life cycle of rice plant can be classified into 5 stages.

1. Seedling (sowing to transplanting)
2. Active vegetative stage (Transplanting to maximum tillering stage)
3. Vegetative lag phase (Maximum fillering to panicle initiation)
4. Reproduction stage (PI to flowering)
5. Ripening stage (Flowering to harvest)

1. Seedling stage (Nursery stage) : Germination to transplanting. Seed germinating to time when young plants becomes independent of food reserve of the seed i.e. nursery stage.

2. Active Vegetative Stage (Transplanting to Max. tillering stage) : This includes sub stages viz.,

a) Recovery stage

b) Rooting stage

c) Maximum tillering stage

The transplanted seedlings need/require about 9 days to recover from the shock of uprooting during transplanting after which new roots appear. It is also known as recovering and rooting stage. Once the plants have good established roots, tillers develop rapidly and increases to a maximum number. Tiller height and straw weight also increases during this stage.

The tiller number increases until maximum tiller number is reached, afterwhich some tillers die and tiller number declines and then levels off.

3. Vegetative lag stage (Maximum tillering to panicle initiation) : It includes sub stages

(i) Effectivce tillering stage

(ii) Non effective tillering stage

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

The visible elongation of lower internodes may begin considerable earlier than the reproductive phase or at about the same time.

4. <u>Reproductive stage (PI to Flowering) :</u>

Pancile development continues and young panicle primordium becomes visible to naked eye in a few days as a transparent structure 1 to 2 mm long with a fuzzed or spongy like structure. The developing spikelets then become distinguishable.

Bulging to booting and panicle emergence from flag leaf and sheath is called "heading". Anthesis or flowering/blooming begins with the protrusion of the first dehiscing anthers in the terminal spikelets on the panicle branches.

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".

The reduction division of pollen mother cells and embryo sac mother cell takes place at this time. The young panicle emerges from the "boot". Anthesis takes place (self), fertilization follows. This is known as "Heading & Flowering".

A large amount of water is consumed in the major part of the reproductive growth period. Drought during paricle primordial initiation to flowering stage impairs panicle formation, heading, flowering and fertilization and leads to increased sterility and ultimately decrease yield.

Pollination and fertilization follow after flowering. The development of the fertilized egg and endosperm becomes visible a few days following fertilization.

5. <u>Ripening State (Flowering to harvest) :</u>

This includes the substages of grain viz., milk, soft dough, hard dough & fully ripe stages (milky ripe, soft ripe, waxy ripe and fully ripe stages). Panicle weight increases rapidly. Staw weight decreases.

During vegetative growth period, a relatively small amount of water is needed. Therefore shortage at this period does not greatly affect the yield, except at the recovering and rooting stages. Stages after panicle primordial development, especially booting, heading and flowering stages need sufficient water.

Duration of growth Stages of Rice plant (approximately)

	Growth Stage	*Duration (days)*		
		Low	*High*	*Medium*
1	Emergence to transplanting	30	25	20
2	Active veg. stage (Transplanting to max. tillerting)	25	25	25
3	Lag vegetative growth (Max. tillering to PI)	25	15	5
4	PI to heading	33	33	33
5	Heading to flowering	7	7	7
6	Flowering to maturity	35	30	25
		155	135	115

<u>Growth phases in relation to yield</u>

Y = f (Panicles/Plant, filled spikelets/panicle, test Wt or Wt of one grain)

No of panicles/plant is determined during the vegetative phase, No of spikelets/paricle is determined during reproductive phase and weight of single grain during the ripening phase.

Adequate LA is necessary for the manufacture of assimilation products required for the development of a large number of spikelets in a pancle.

Number of spikelets/panicle depends upon the activity of plant during the reproductive phase. It shows +ve linear regression with 'N' content of plant during this stage. The photosysthetic activity during the reproductive phase also controls the number of spikelets/panicle, (as shading experiments demonstrated).

Plants with adequate 'N' uptake in each phase of growth give high yield with large leaf area + adequate N. The plants manufacture a large amount of carbohydrates during reproductive and ripening phases. However, excessive 'N' applications induces spikelet sterility.

The starch in rice grain comes from 2 sources

(a) the assimilated products before flowering (in the culm and leaf tissues) and later transformed into sugars – " this is called accumulated starch"

(b) the assimilated products produced during the ripening phase.

Starch coming from 1st source is hereafter called "accumulated".

A short duration variety has a smaller proportion of accumulated starch than a long duration variety and at high 'N' levels, the proportion of the accumulated starch is smaller than at low N level.

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Lecture No: 3

Classification of rice plant types

Rice (Oryza sativa) belongs to the family Graninae of Poeceae and subfamily panicoidae. There are 24 valid species of oryza, of which 22 are wild species and 2 are cultivated species. The 2 cultivated species are

1. O. sativa present in Asia, Europe and America
2. O. glaberrima present in Africa.

Rice has been cultivated for thousands of years under widely different geographical or agro climatic regions. During this long period, a multitude of forms and varieties have been evolved. Based primarily on geographic adaptation and morphological characters of the cultivated oryza rices, the world can be broadly divided into 3 sub species Viz., Indias, Japonicas and Javanicas.

The classification between the sub species are not absolute, but are based on morphological characters or also adaptations to temperature and photoperiod conditions prevailing in different rice growing regions of the world.

Characters of 3 races

	Character	Indicas	Japonicas	Javanicas
1	Leaves	Very broad to narrow, pale green	Narrow, dark green	Broad, very stiff, light green
2	Grain quality	Long to short, slender, somewhat flat	Short, roundish	Long, broad, very thick grains
3	Tillering	Profuse	Medium	Low
4	Height (stature)	Tall to intermediate	Short to intermediate	Tall
5	Awn	Mostly awnless	Both awned & awnless	Both awn & awnless Eg: HR 19, 47
6	No of ears & ear weight	Many & light	Many & heavy	Few and heavy
7	Hairs on leaves and glumes	Present	Present, dense	Present but are very long
8	Plant tissue	Very soft	Very hard	Very hard
9	Sensitivity	Varying	None to low	Low
10	Flag leaf	Narrow & long	Narrow & short	Broad & long
11	Varieties from	India, Southern China, Taiwan, Ceylon, Java & other regions	Japan, Korea, N. China	Small no of varieties from Indonesia.

1. <u>INDICAS</u> : 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. <u>JAPONICAS</u> : These are temperate region varieties dwarf in stature with sturdy stems & thus non lodging. Leaves short, thick, narrow, dark green colour, making medium angle with main culm. They are awnless to awned varieties, grains are nearly round and fertilizer responsive vartieties.

3. <u>JAVANICAS</u> : These are intermediatory to Indicas and Japonicas, having morphological resemblance to indicas. Adopted to low atitudes. They are called "BULU" varieties, low tillering and sensitive to photoperiod (equatorial belt of Indonesia)

   Ex : HR 19, 47

RICE SOILS

Rice is adptable 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 it self.

Rice is grown in all types of soils in AP, the best soils are clay loams, the characteristic of deltas. These soils become soft to very soft on puddling and crack deep when dry.

The semi acquatic 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 PH. Redsoils, black soils and laterite soils are also suitable.

In Punjab & Haryana ? rice is grown in light soils due to high water table.

In AP? rice is grown in all types of soils.

Best soils are CLAY LOAMS (Deltas)

REGION	1st crop (Kharif)	2nd crop (Rabi)	3rd crop (Summer)
Coastal Andhra	Sarva (Jun-Nov)	Dalwa (Nov-Mar)	Summer (Mar-July)
Telengana	Abi (Jun-Nov)	Tabi (Dec-April)	Kathera (Mar-July)
Rayalaseema	Vanakaru (June-Dec)	Endakaru (mungari) (Nov-Mar)	Hingeri
North India	Autumn	Aman	Boro

Lecture No : 4

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 imperveous sub soil layer for reducing deep percolation & leaching losses.
6. To facilitate easy transplantation.

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

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 form an a erobic environment to an anaerobic or near anaerobic environment where O_2 is limiting. The flooded or waterlogged soils develops two zones:

1. The upper zone: a thin 1 – 10 mm thickness, absorbs O_2 from the water and turns brown in colour (Oxidized zone) and reacts to N like an unflooded upland soil.

2. The lower zone: the remaining lower portion of the puddle soil truns to a dark or blue green colour as iron compounds in the flooded soils lose their O_2. This soil zone is said to be in reduced state.

Redox Potential (Eh) : It gives an indication of oxidized reduction potential. It is measured in m.v. (+700 to -700)

Highly reduced soils	?	-300 to -100
Reduced	?	0 to +100
Moderatly reduced	?	+200 to +350
Aerated oxidized	?	+350 to +450

Sequestial chemical changes that occur during submergence and puddling in rice

1. Depletion of O_2 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 NO_3 and NO_2 to N_2 and N_2O
6. Reduction of SO_4^{-2} to 5-2 i.e. extremely reduced conditions.
7. Increase in the supply of availability of N
8. Increase in the availability of P, Si & Mo
9. Decrease in the concentration of water soluble Zn & Cu
10. Generation of Co_2, Methane (CH_4) & toxic reduction products such as organic acids and H_2S.

(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 NH_4 form (stable under water logged conditions) and denitrification losses will take place.

(c) Chemical changes :

? Increase in solubility of P
? Reduction of SO_4 to sulphide (Injurious form)

Lecture No: 5

METHODS OF PLANTING :

Direct seeding/transplanting is adapted in low land rice after puddling.

Conditions congenial for direct seeding :

Seed rate ? 60 to 80 kg/ha

Spacing ? 20 to 30 cm

(Solid rows) 3 cm depth

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

Total growth period	Age of the seedling for transplanting (days)
120	25
135	32
150	35
180	42
HYV's	21-25
Dapog	4-6 seedlings/hill at 14 DAS
SRI	1 seedling /hill at 25X25 cm or 30X30 cm at 12 days after sowing

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 ar 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 No: 6

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.

The requirement of 'P' is not as high as that of 'N' Wide spread 'P' deficiency in rice soils and responses of rice to the applied 'P' are observed in the country.

Efficient use of fertilizers :

Fertilizer use efficiency (FUE) is low in rice crop. 40% of applied 'N' & 26% 'P' alone are recovered by rice crop in India. There is a need to increase the efficienty of use of applied nutrients by applying the right form, right quantity at the right time & by the right method. (F Q T M)

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 two times

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 P1 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. NH_3 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.

Some general guidelines based on no of trails conducted under AICRIP have been summarized by ten Have (1971).

1. If reflooding is not problem, top dressing may be given for every 2 ½ -3 wks between transplanting/sowing and about a week before P1 @ 20-30 kg N/top dressing.
2. More N should be applied at planting with soils low in N. Soils with adeluate N ⟶ the emphasis should be on proper top dressing.
3. Permeable soils ? relatively low N top dressing should be given more frequently.
4. For early maturing varieties, low tillering varieties ? relatively more 'N' should be given at early growth stages.
5. For long duration varieties & slow initial growth due to cool conditions Relatively more N should be given as top dressing.
6. For varieties sensitive to BLB Moderately top dressing each with a smaller amount of N.
7. For direct sown rice ? Less N should be applied at sowing. More N as top dressing.
   Too much 'N' at sowing ? reduces seedling establishment due to strongly increased algal development, 'N' is lost and weed growth increases.
8. More 'N' (1/4 extra dose) should be applied as basal dressing for aged seedlings. Less 'N' at planting is needed if very young seedlings are transplanted as with a Dapog system.
9. For deep water rice ? Emphasis should be on good basal N application. Application of N > 40 kg/ha is found to be harmful.
10. For rainfed crop, small amount of N should be given as a basal dressing followed by a few top dressings preferably on rainy days.

Long duration varieties ? require relatively more N as top dressing.

METHOD OF APPLICATION OF N :

N is lost through fertilizers as

1. Surface runoff
2. NH_3 volatalisation
3. Leaching
4. Denitrification

Soil characteristics, weather conditions and management practices determine the extent of losses. The losses can be reduced considerably by adopting better management practices.

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.

Sources of N

1. Ammonia containing or NH_4 forming (Eg. Urea) fertilizers can be used either for preplant or top dress applications.
2. NO_3 sources have to be considered for top dressing everthough its effectiveness is usually somewhat less compared to pure ammonium N sources (NH_4Cl, NH_4SO_4, Amm.phos, DAP)
3. $(NH_4)_2$ SO_4 is regarded as superior source to NO_3 forms in all except in very acid soils (or) on strongly leached (or) impoverished soils.

Urea is the highly popular N source of fertilizer for wet rice growing areas because of its high grade analysis. It should be preferred in degraded paddy soils.

1. Its hygroscopic nature which results in poor handling properties.
2. Its N losses through volatilization as NH_3 when urea is applied to surface soils.

   Urea ? $Co(NH_2)_2$

3. Urea is hydrolysed to $(NH_4)_2 Co_3$ through the enzyme, urease

4. Urea in relative to ammonium is very weakly adsorbed by colloidal particles.

5. Being highly soluble in water, the dissolution, hydrolysis or nitnification of urea N may be completed in only 7 days after its application and is subjected to various loss mechanisms.

Efforts have been made to related the rates of dissolution, hydrolysis, nitrification of urea by (1) altering its granule size and (2) coating or treating it with different materials.

Use of slow release N fertilizers so that N release matches with N uptake by rice crop.

(Use of slow release N fertilizer-so that N release matches with N uptake by rice crop. Use of pre incubated urea ? 1 kg urea mixed with 5 kg soil; shade dried up to 36-48 hrs); use of mud balls ? prepared mud balls of moist soil and put urea in the centre of the soil.

USG, SCU, LCU, LGU, CTU, Rock phosphate CU, GCU, NCU are the various modified & coated urea materials.

Because of their large granule size, LGU, USG have much lesser total surface area exposed to soil water than the equivalent amount of prilled urea.

IBDU ? Isobutylidine di urea

Slow release compounds : Use of urease and nitrification inhibitors alongwith urea could retard the hydrolysis and nitrification rates respectively and thereby reduce N losses through NH_3 volatalisation and denitnification processes.

1 PPD ? Phenyl phosphorodiamide at 26 DAT increased N uptake.

NBPT ? N butyl thio phosphoric triamide. It is more effective than PPD (Urease inhibitor)

Nitrification inhibitors :

Urea with 10% or 15 % DCD (Dicyandiamide) applied during the final harrowing produced comparable yields to those of split application of urea.

N-Serve ? 2 chtoro 6 trichloro methyl phridine (USA)

AM ? 2 amino – 4 chloro 6 methyl pyrimidine (Japan)

Nitrification and urease inhibition properties of non edible oil cakes such as neem, karanji, hahua, Sal, Kusum, undi etc., could be utilized to improve NUE.

Use of urea coated with 10% or 30% of different non edible oil cakes have proved to be encouraging (urea coated or blended with indigenous materials).

Neem cake blending with urea

½ kg coatlar + 1 lit Kerosene oil + 20 kg neem cake + 100 Kg urea

FUNCTION OF N

1. Imparts dark green colour to plant growth.
2. Promotes rapid growth
3. Increases size of leaves and grains
4. Increases protein content in grains
5. Improves quality of crops
6. Supplies N to maicrobes while decomposing low N organic materials.

DEFICIENCY OF N

1. Stunted growth
2. Appearance of light green-pale yellow leaves
3. Reduced tillers
4. Flowering is greatly reduced & yield decreased
5. Results in lower protein contest.

PHOSPHORUS :

Recovery of P = 26%

Rates of application :

Results showed that application of 60 kg $P_2 O_5$/ha for red soils and 80 kg $P_2 O_5$/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 – Soil available $P_2 O_5$) x 3/2

For black soils : (40 – Soil available $P_2 O_5$) x 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 PO_H 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 m^2 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.

FUNCTIONS OF P :

1. Stimulates root development
2. Promotes earlier flowering and ripening (especially in cool climates)
3. Encourages more active tillering under adverse conditions.
4. Promotes good grain development and gives higher food value. P content of grain.

‘P’ DEFICIENCY SYMPTOMS

1. Stunted plants with less number of tillers.
2. Leaves narrow & short i.e. erect and dirty dark green.
3. Young leaves healthier than older leaves which turn brown and die.
4. Reddish or purplish colour due to production of anthocyanin pigment.

POTASSIUM MANAGEMENT

Soil test values showed that adequacy of available soil potash except Ananthapur where it is low; a few packets of red soils in chittore & Nellore black soils and Cuddapah have shown to respond to potash application. 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 dificiency 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.

FUNCTIONS OF K :

1. Increases vigour and diseases resistance in plants
2. Helps in protein production of plants
3. Strengthens the straw and stalks of plants.
4. Helps in root development
5. Helps in formation and transfer of starches, sugars and oils.
6. Induces plumule development of grains

K deficiency Sympotms

1. Interveinal chlorosis near margins, scorching & browning of tips of older leaves.
2. Slow and stunted growth of plants
3. Stalk become weak and plant lodge easily.
4. Shrivelled seeds
5. Disease and pest susceptibility of plants.

Nutrient removal by some HYV'S

Variety	Season	Grain yield (kg/ha)	Nutrient removal (kg/ha) N	P	K
IR-8	Khafif	6308	95	25	149
	Rabi	6739	99	23	124
Jaya	Kharif	6136	84	25	147
	Rabi	6635	105	23	129
Locals	Kharif	1942	43	13	49
MTU-15	Rabi	3242	41	13	65

Steps for increasing F.U.E.

1. Apply right quantity at night time (i.e. split application) by right method
2. Adopt root zone placement of N fertilizers
3. Follow balanced fertilization ? 80 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha (2 : 1.5 : 1) is very economical. Moderate response can be had with a dose of 60-30-30 (2 : 1 : 1).
4. Integrated/supplementary use of organic manures (including green manures) and biofertilisers.
5. By correcting micronutrient deficiencies (especially zn)
6. By maintaining adequate plant population (400-450 panicles/m^2)
7. By following proper water management practices (continuous submergence of not more than 2 cm depth)
8. By adopting effective weed control and plant protection measures.

ZINC DEFICIENCY

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

1 Unit increase in PH ? makes zn 1000 times less soluble.

Alkaline soils with high organic matter aggravate zn deficiency

NP ? ? ? zn

(If N & P is increased the uptake of zinc is decreased)

FUNCTIONS OF ZINC :

1. Probable connection with production of auxins.
2. Activaton of many enzymatic reactions.
3. Close involvement in N metabolism.

Zn deficiency Symptoms :

1. The mid ribs of younger leaves especially base become chlorotic.
2. Appearance of brown blotches and streaks on the lower leaves followed by stunted growth .
3. The size of leaf blade is reduced but not leaf sheath
4. Uneven growth and delayed maturity in the field

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.
4. Varietal tolerant to zn deficiency ? IR8, 28, 30 & 34

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 atemperature of 25-45^{0}C and PH 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 occuring 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 temparatures. It grows at a temperature of 20-30^{0}C 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 No: 7

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 flows where irrigation and drainage facilities are available.

Water requirements of rice at different growth stages

	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	P1 to 21 DA flowering	5
7	21 DAF to harvest	Gradual drainage of water

In AP ? 94% of the rice area is irrigated

Canals ? 50.6

Tanks ? 29.4

Wells & filter points ? 14.4

Rainfed ? 5.6

100.00

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

Continuous flooding with 5-7.5 cm of water depth is however, the best system in achieving higher yield where no water shortage is felt.

Total water requirements of rice crop

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

They are : water needed to

1. raise seedlings or nursery
2. preparation of main field
3. to grow a crop of rice from transplanting to maturity or harvest

The amount is determined by many factors.

i) Soil type
ii) Topography
iii) Proximity to drains
iv) Depth of water table
v) Area of continuous rice fields
vi) Land preparation methods
vii) Duration of crop
viii) Evaporative demands of the growing season

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 : (rice crop from transplanting to harvest)

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	Pl 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

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

RICE-IRRIGATION WATER MANAGEMENT

Water requirement : Water requirement is the quantity of water regardless of source, needed for normal crop growth and yield in a period of time at a place and may be supplied by precipitation or by irrigation or both.

WR = CU + Application losses + water needed for special operations

CU = ET + Metabolic activities of plant

WR = IR + ER (Effective rainfall) + S (Ground water contribution)

Water requirement of crop depends upon

(i) Crop factors such as viz., growth stage, duration, plant population & growing season

(ii) Soil factors such as texture, strucdture, depth and topography

(iii) Climatic factors such as temp, RH, wind velocity

(iv) Crop management practices such as tillage, fertilization, weeding etc.,

(v)

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

CRITICAL STAGES

During certain stages of growth, 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

Primordia development, 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

WUE = Y/ET

(kg/ha mm of Y = yield

Water) ET = Evabotranspiration

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 No: 8

Weed control : 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.

Transplanted rice ? 15-20% loss

Direct seeded rice ? 30-35% loss

(puddle soil)

Upland rice ? 50%

The potential loss in production of rice in India due to weed infestation is estimated at 15 m tons/annum.

WEEDS : 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) Benthiocarb (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. 2, 4-Dielthyl ester granules at 10 kg/ha + benthiocarb 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) 0.4 kg a.i/ha +1.25kg ai/ha
3. 2,4-Diethyl ester granules at 10 kg/ha + benthiocarb at 2.5 lit/ha mixed with sand and applied at 3-5 DAT will be effective when the fields are infested with cyperus and other weed species. (cost Rs.512/ha) 0.4 kg a:i/ha +1.25kg ai/ha
4. Anilophos @ 1.33-1.67 lt/ha mixed with sand and applied 3-5 DAT
   (Cost Rs.240-300/ha) 0.4 kg ai/ha.
5. Butachlor @ 4-5 lit/ha mixed with sand and applied
   (Cost Rs.500-625/ha

Upland rice

(i) Application of 2.4-Dmine @ 0.9 kg a.i./ha mixed in 600 lit of water at 30-35 DAS was found useful.

(ii) Direct seeded low land rice ? 2, 4.D ester @ 0.9 kg a.i./ha at 25 DAS was found effective.

2, 4 D Na salt (Fernaxone) can be sprayed @ 0.75-1 kg/ha at 25-30 DAT when the fields are infested with broad leaved and other susceptible weeds.

ROUGING : Roughing is the removal of off types from the main field. Though it is not cultural operation, it is necessary to maintain purity of seed which is taken up at the following stages of the crop.

a) A flowering (due to varieties)

b) At milk stage

c) At full maturity

d) At harvest

HARVEST : (Physiological maturity)

Turning the crop colour from green to yellow is the general symptom of maturity. At this stage, the grain starts maturing from top to bottom of the panicle. About a week for heavy & 3-4 days for light soils, prior to harvest, the water is let out completely and alley ways (pathways) at 10'-15' made apart by parting the crop.

harvest, ? moisture level of grain should be 20-23% for better milling quality.

In single cropped wet lands, either a pulse (Eg:BG/GG) or fodder crop like pillipesara/sunhemp seed is broadcasted. Then the rice crop is harvested by manual labour using sickles. The harvested sheaves are spread for 3-4 days, sundried and heaped and directly threshed, winnowed & stored.

For shattering varieties, crop is harvested before it is fully dried.

At the time of harvest, the bottom portion of plants and some of the grains at the base of the earhead will be green. If it is fully riped (dead ripe), the rice gets broken during milling.

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. <u>Cattle thresing</u> : 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. <u>Tractor threshing</u> : 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.

<u>YIELDS</u> : 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 <u>rabi</u> for HYV.

<u>Productivity of rice in different districts of A.P.</u>

2.5 t and above ? W & EG ? 23%

2.0 t to 2.5 t ? Krishna, Guntur, Cuddapah, Nalgonda Khammam ? 34%

1.5 t to 2.0 t ? NLR, Kurnool, Rangareddy, Hyderabad, Nizamabad, Medak & Warangal ? 22%

1.0 t to1.5 t ? Srikakulam, Vizianagaram, Prakasam, M. B. Nagar, Khammam, Adilabad ? 18%

< 1.0 t ? Rest 3%

<u>By products</u> : The ratio of cleaned rice to paddy is

65-70% by weight

50-55% by volume

Rice husk16 lakh tons/year used as cheap fuel and bedding in poultry houses under deep litter system.

Standard wt of bags is 75 kg including bag wt.

Rice bran 3 lakh tons/yr Rice bran contains 12-14% rice bran oil (Branola) prescribed for heart patients.

A.P is a surplus in rice.

58% of the production is diverted in the market every year out of which 8-10 million tons are exported to other states.

35% is retained by farmers for domestic consumption.

5% payment of wages in kind

2% used as seed.

PAR BOILING of rice is also done in certain rice mills for exporting to other states like T. Nadu, Kerala. Not only outturn of rice is more in parboiling, but its nutritive value too is highest.

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.

YIELD & YIELD ESTIMATES OF RICE

Yield can be estimated when we have data on the following :

1. Nº of tillers /unit area
2. Nº of panicles/unit area
3. Average Nº of grains/panicle
4. % of filled grains
5. Weight of grain

Yield = (2) x (3) x (4) x (5)

Through the estimated yield differs fomr actual yields depending upon uniformity of the field sampled, greater crop uniformity results in precise estimates. Efforts in sampling for each one of the components may lead to either over or under estimate of crop yields.

Ex: AV. Nº of tiller/m^2 = 500

% of productive tillers = 80%

Nº of panicles/m^2 = 400

AV Nº of grains/panicle = 120

% of filled grains = 75

Wt. of the grain= 0.027 gm

Yield/m^2 = 400 x 120 x 75/100 x 0.027

= 972 g/m^2

= 9720 kg/ha

<u>Reasons for low yields of rice</u>

1988-89 ? 1666 kg/ha

1990-91 ? 1776 kg/ha

1993 ? 1742 kg/ha

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 phgotosymnthetic 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 conditiuons.
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 Kg 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 thr ough 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.

Chemical composition of rice grain

1.	Carbohydrate	76-79 %
2.	Protein	6.4-85 %
3.	Fat	0.4-1.4 %
4.	Crude fibre	0.1-0.6 %
5.	Energy value	3470 k.cal/kg
6.	Ash	1.9 %

Vitamins (ppm)

Thiamine (B1)	3-5
Rhiboflavin	0.8-1
Nocotinic acid (Niacin)	55
Pantothenic acid	17

Minerals

Ca	0.084
P	0.290
Fe	0.002

Rice grain classification:

Ramaiah committee (1969) suggested the following classification of rice grain of raw brown rice.

	Class	Length (mm)	L : B ratio
1	Long slender	6 or more	3 or more
2	Short slender	< 6	3 or more
3	Medium slender	< 6	2.5-3
4	Long bold	$\geq$ 6	< 3
5	Short bold	< 6	< 2.5

PARBOILING :

A hydrothermal treatment of rice grain immediately followed by drying prior to miling 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 of parboiling :

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 contest 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.

Rice based cropping systems

Rainfed rice

Rice – fallow/sesame/pulses

Rice – fallow

Lowland rice

Rice – wheat/barley/fallow

Rice – fallow/sesame/pulse

Rice – rice –Rice/fallow

Rice – wheat – Jute/fallow

Rice – Potato

Medium land (irrigated)

Rice – wheat/barley/fallow

Rice – chickpea/linseed

Rice – wheat

Rice – Fallow/sesame/pulses

Fallow – rice – Sugarcane

Canal irrigation

Rice –Rice – Pulse

Rice – Sugarcane

Rice – Pulse/sesamum

Well and Tanks

Rice – Pulse / groundnut

Dry paddy? It is grown as intercrop with red gram

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 grains.

Lecture : 9

W H E A T

Wheat is the world's most important grain crop. Wheat rank first position in the world among the cereals both in respect of area and production. It is a crop that primarily grown in temperature regions. It constitutes the staple food in at least 43 countries. The most important wheat growing countries are the USSR, USA, China, India, Canada, Argentina, Australia and a number of European countries.

In India, it is the second important food crop being next to rice and contributes to the total food grain production of the country to the extent of about 25%. It is consumed mostly in the form of pan baked bread, called 'chapathi'. Wheat straw is used for feeding the cattle. The introduction of Mexican dwarf wheat varieties in the mid 1960's revolutionized the wheat productivity as well as its total production in India. Wheat contributed to the lion's share in the Green Revolution.

Statistics :

2001-02 India : Area 26.6 m.ha.
Production 72.1 m.t
Productivity 2703 kg/ha

2007-08 A P : Area 12000 ha.
Production 7100 t
Productivity 592 kg/ha

Chemical composition of wheat grain

Starch : 60 - 6 8 %

Protein : 8 %

Fat : 1 ½ -2

Cellulose : 2-2 ½ %

Minerals : 1 ½ -2%

ORIGIN : Form the earliest times, it has played an important role in the development of civilization. The origin of cultivated wheat, like most of crop is lost its antiquity. The origin is supposed to be South west Asian countries from where it spread to European countries. Its cultivation is known in 17th century off atlantic coast. The Aryans are supposed to have brought it to India.

Several forms of wheat were cultivated as back as 10000-15000 BC in N-E. The tatraploid and hexaploid species of wheat originated from the wild diploid species by mutations and hybridization resulting in a wide range of adaptability in the modern wheat. The most important cultivated wheat sps are

T. aestivum	(hexaploid)	2n = 12
T. durum	(Tetraploid)	4n = 28
T. sphaerococcum	(hexaploid)	6n = 42

T. sphaerococcum has now practically gone out of cultivation because of its (1) low productivity and (2) high susceptibility to diseases.

T.dicoccum or emmer wheat is grown on a very restricted scale in Gujarat, Maharashtra, A.P and T.Nadu where it is known under the names of popatya, Khapli, ravva godhumalu and samba respectively. It is preferred for granular properations. Ex : Upma

T.aestivum, the common bread wheat is by far the most important sps, occupying about 85% of the total area under wheat. It is grown all over the country from sea level upto elevation of 3658 m in the Himalayas.

T.durum, the macaroni (&SUZI) wheat is the 2nd most imp sps of wheat occupying about 14% of wheat area. Its cultivation is confined to central and southern India only. It was under cultivation at one time in Punjab & WB, but now has been compledtely replaced by the bread wheat i.e. T.aestivum.

Area under wheat steadily went up in the recent years during wheat revolution. In India, during 1947, it had 9.2 m ha under this crop. In the last few years it' acreage rose to a little over 25 million ha (1996). In terms of production and acreage, India ranks 2nd place among the wheat growing nations of the world-the top countries in this respect being China, India, USA USSR, Canada, Australia in that sides.

CLIMATE : Wheat is mostly a winter crop. It requires cool temp ' during early period of growth. The tillering is favoured by cool conditions. Cool nights at seedling stage helps in utilizing the carbohydrates of the seed which results in better growth of the plant. Generally grow in

temp ? 2.2^0c-26.4^0 c

opt. temp ? 21.1^0c

Wheat requires ? Moderate amount of

Soil moisture and low humidity which favour early ripening and reduces lodging as a result of which the crop escapes from rust attack.

Wheat is grown in areas with annual rainfall varyin from 375-1750 mm optimum annual rainfall required by crop is 750-1000 mm

In India, wheat is grown in areas with annual rainfall varying from 125-1125 mm. It can also be growth in high attitudes. It is grown in Kashmir at an attitude of 2000-3000 m MSL. Wheat crop takes 180 days in hills of North India; western region and 100 days in Peninsular India for maturity. It can tolerate severe cold and snow and resume growth with the setting of warm weather. Best wheats are produced with cool moist weather during major portion of growing period (dry warm weather during grain ripening period)

SOILS : In India, wheat is grown in different soils; but it does well on well drained loams and clay loams. Best growth is achieved in allurial soils of Gangetic plains; but it does also well on black cotton soils of central India.

SEASONS : In India, wheat is grown during rabi or winter season. The high temperatures on both ends of wheat season restrict the cultivation of this crop in India. Too cooler months, high temperatures in September do not permit good tillering of the crop. They also favour root rot and seedling blight. Hot summer during the grain ripening period hastens the maturity of the crop giving infertor quality of the crop.

Wheat can be successfully grown in Telangana & Rayalaseema areas where the required conditions prevail. Sown in mid November, the crop is ready for harvesting by the end of February to 1st wk of March.

Preparatory cultivation :

It requires well pulvenised but compact seed bed for good and uniform germination. 3-4 ploughings in summer, repeated harrowing in the rainy season followed by 3 or 4 cultivator workings and planings immediately before sowing produce a good fine seed bed for the dry crop on alluvial soils. Timely cultivation and conservation of moisture are essential.

In black cotton soils ? blade harrow is used instead of the plough. 1 to 3 ploughings with an iron plough may sometimes precede the use of blade harrow.

For irrigated crop? the land is given a pre sowing irrigation and the number of ploughings is reduced.

Where white ants and pests are problem ? Aldrin & BHC 10% @ 25 kg/ha

Methods of sowing : 5 methods

1. Broadcasting
2. Sowing behind the plough with hand
3. Sowing behind the plough with seed drill
4. Dibbling
5. Transplanting

1. Broadcasting ? Scattering of seed by hand followed byploughing/harrowing. Cheap and quick method very inefficient and requires heavy seed rate.

2. Sowing behind plough with hand

A boy/woman follows a plough and drops seeds in the furrow.

It is mainly followed on irrigated lands.

3. Sowing with seed drill : Seed drills are generally used for sowing on barani lands (dry) (rainfed) Seed drill is one row drill attached to a tube with funnel shaped mouth ( ) into which the man drops the seeds.

The seed is deposited at the bottom of the furrow and then light planking is done.

4. Dibbling : Dibbling 2 or 3 seeds by hand at 4-6 cm depth at a distance of 22.5 cm between rows and 10-15 cm between plants in a row. It is a good method for quick multiplication of pure seed material on a small scale.

But it is laborious and time consuming for large scale sowing.

5. Transplanting : seedlings are raised in the nursery. About 3-4 weeks old seedlings are transplanted in well irrigated fields. It is a good practice of sowing wheat in late season but it is a time and labour consuming method.

TIME OF SOWING :

Optimum time ? 1st FN of November. If early sowing is to be done, sow it towards the end of October using a variety like Kalyanasona. For late sowing, the varieties of less than 100 days duration like up 301 or Hira-sowing can be done upto the end of November.

SPACING :

Unirrigated (Rainfed) areas ? 30 cm row to row

Irrigated areas ? 22.5 cm row to row with 2 seeds/hill is found better.

Under favourable conditions : 30 cm x 10-15 cm with 2-3 seeds per hill is good method in dibbling by hand.

Depth of sowing :

For dwarf wheats, depth should be between 5-6 cm. Planting/sowing beyond this d epth results in poor stand.

? In case of conventional tall varieties the depth of sowing may be 8 or 9 cm.

? Deeper sowing is practiced (6-7 cm) under rainfed conditions where as shallow sowing is done under irrigated conditions.

SEED RATE :

? Heavy seed rate of 100-125 kg/ha is required for bold seeded and shy tillering varieti es like sonalika.

? For medium sized grain varieties ? 75-100 kg/ha (Eg: Kalyan Sona)

? For late sown crop ? 125-140 kg/ha ? Under rainfed conditions 100 kg/ha

In AP, wheat does not tiller profusely hence use the recommended seed rate.

SEED TREATMENT : Seed treatment with Thiram 0.2% against seedling blight captan @1:300 parts by weight of seed can also be used (i.e. 10 g/3 kg of wheat seed)

INTERCULTIVATION : Weeds are to be controlled during the early stages of crop growth and to give slight earthing up. A light plough or Danthi can be worked in between lines.

FERTILISERS

The rainfed wheat is not fertilized by farmers due to economic reasons.

It is desirable to apply 2-3 t of FYM/ha at 5-6 weeks before sowing.

40 kg N + 20 kg P_2O_5/ha will give a considerable boost to wheat yield if it is to be applied at 10 cm deep (3-4 cm below the seed) at or before sowing of seed.

For irrigated wheat : 120-60-40 kg NPK/ha

Entire P & K and ½ of N should be applied 5 cm below the seed at the time of sowing. Remaining ½ N should be applied at the time of 1st irrigation irrigation i.e. at the CRI stage (i.e. 21 DAS)

In case of Zn deficiency, 25-50 kg $ZnSO_4$/ha is to be applied as a basal dose in the soil.

STAGES OF CROP GROWTH :

There are 5 important stages. Adequate soil moisture is an important factor at these stages.

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

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

3. JOINTING STAGE : It represents the node production and active growth period. Upto this stage, the seedlings consists of a whorl of leaves. At this jointing stage, the stem becomes visible with distinct nodes.

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

5. GRAIN DEVELOPMENT : It is upto the end of soft dough stage of the grain. At this stage also, the plant requires adequate moisture at dough stage.

Lecture No.10

WEED CONTROL :

For non graminaceous broad leaved weeds spray 2, 4-D @0.4 kg a.i/ha in 750 lit of water between 4 and 6 weeks after sowing. Spraying before or after this specific period will be harm full the wheat crop too.

For graminaceous weeds like phalarris minor and wild oats, a preemergence application of tribunal @ 1.5 kg ai/ha dissolved in 750 lit of water controls them (or) spray a mixture of 2, 4-D-ethyl ester with isoproturon/tribunal.

IRRIGATION :

A life saving irrigation is necessary for uniform germination and good plant stand. Total water requirement is 300-400 mm.

In light soils (which tend to form hard crust), irrigate and then sow the seed. In heavy soils ? it is better to sow in dry soil and then irrigate. Thereafter, 4 irrigations are quite essential during the following critical stages of crop growth.

i) CRI (15-21 DAS)
ii) Jointing (45 DAS)
iii) Heading (65 DAS)
iv) Dough stage (85-90 DAS)

Under limited water supply, if irrigation water is available –
if only one irrigation is available ? Apply at CRI
if only two irrigation is available ? CRI & Dough stage
if only three irrigation is available ? CRI + heading + Dough stage

In wheat the time of irrigation is more important than the number of irrigations. In light soils ? crop should be irrigated frequently. In heavy soils with high moisture storage capacity the no of irrigations can be reduced. In black soils of heavy texture (where more moisture at the time of sowing of crop) ? even the irrigatgion at CRI stage does not seems essential.

The conclusions drawn based on the experiments conducted on irrigation of wheat are :

1. Given with short growth durations, the water requirements of dwarf wheat is higher than the tall varieties.
2. Irrigation may be given when ASM% has gone down to 40-50% in top 60 cm depth.
3. It has been observed that there is steady rise in cumulative use of water upto grain filling stage of plant after which it falls steeply from grain filling to harvesting.
4. During early stages, the cumulative use of water by these varieties has been found ranging from 0-70 to 0.85 mm/day which ircrease with advance of season even upto 4 mm/day.
5. Irrigation at CRI and milk stages is very necessary since these stages are most critical for irrigation.
6. Since the rooting depth at early stages is very shallow (15-25 cm), initial Irrigations should be given with less amount of water, the later irrigations should be given with sufficient water (6-7 cm/irrigation)
7. Border strip method of irrigation is the best method for effective water distribution.
8. Where water supply is scarce, irrigation at tillering to late joiting can be avoided.

For long duration varieties scheduling of irrigation is a s follows : 6 stages are recommended.

CRI ? 21-25 DAS

Late tillering ? 25-60 DAS

Late jointing ? 60-70 DAS

Flowering stage ? 90-95 DAS

Milk stage ? 100-105 DAS

Dough stage ? 120-125 DAS

HARVESTING : It varies from time to time and zone to zone and also growing conditions (RF/irrigated)

RF crop ? reaches maturity earlier than irrigated. The same variety behaves differently in respect of maturity in different zones. Eg: Kalyan sona

? In peninsular India-harvested-end of Feb or March begining. Whereas same variety planted at same time in Northern Hills ? is harvested by May-June.

The high temperatures shorten the growing period in peninsular India.

Symptoms : 1. The crop is harvested when the grains harden and the straw becomes dry.

2. Don't allow the crop till it is dead ripe. Harvest the crop while base of the stalks slightly green (   ) to avoid shedding.

3. Non shedding varieties ? They are harvested when the grain is matured fully.

Test : A simple test is to crush a few grains between teeth and the seed should crack (25- 30% moisture)

Shedding varieties should be harvested at when the stalks are slightly green.

Ordinary method of harvesting is by sickle is quite efficient for small holdings but where a large area has to be harvested or higher intensity of cropping is to be followed a bullock reaper is more efficient implement and economical to adopt.

Threshing : Grain is generally threshed by trampling with cattle on a threshing floor. ? Us e of stone roller, saw threshers and tractors also expedite the operation. Simple mechanical threshers ? Eg: Ludhiana thresher & Sherpur thresher are used by some farmers. Threshers are very common in Punjab. Winnowing is done generally with winnowing baskets.

A disc harrow with a light tractor separates the grain and makes the "bhusha" fine. The outturn is 13-19 grain/day. Power worked thresher gives an out turn of 7.5 to 37 q of grain per day depending upon feeding capacity and efficiency of threshers.

YIELD : Rainfed conditions ? 6-11 q 1 ha

Irrigated conditions ? 18-23 q 1 ha

With improved methods of cultivation yield of 27 to 31 q/ha of grain. The yield of straw is generally double the yield of grain.

.. grain :straw ratio is 1 : 2

YIELD ATTRIBUTES :

1. No of productive tillers/unit area
2. Total no of grains / head
3. % of fertile grains/ear head
4. Test weight (1000 seed weight)

STORAGE : The grain should be thoroughly dried before storage. The storage life of grain is closely related to its moisture contest. Grains with less than 10% moisture stores well.

In Eastern India, the storage of wheat grains without losing viability for the next crop is a big problem due to high humidity prevailing in that area.

Structures : The storage pits, bins or godowns should be moisture proof and should be fumigated to keep down the stored grain pests including rats. Zn PO_4 is very effective against rats.

CROP ROTATIONS :

1. Rabi wheat is followed in kharif with crops such as maize, jowar, bajra cotton & arhar.
2. Sometimes green manure crops like blackgram, guar, (lover are sown immediately after the harvest of kharif crop to enrich the soil.
3. with the availability of photoinsensitive varieties, recent emphasis in intensive agriculture, the rotation patterns have undergone some changes.

   In Haryana, Western UP ? rice become an important crop in kharif.

   It is followed by wheat (Rice-wheat)
4. In Eastern India ? Rice-wheat
5. In some states like West Bengal-Rice-Wheat-Jute rotation has become more popular.
6. Sugarcance-Wheat rotation is also common in North India.
7. Where irrigation facilities are available, legume crop is grown in between 2 cereal crops to enrich the soil as well as to get the needed pulses.
8. Black soils of central India & Peninsular Inida, Unirrigated wheat is rotated with jowar, Bajra or cotton in the kharif in the preceeding year.

9. Growing of quick growing crops like blackgram, gingelly, onion or even groundnut or early sown maize as catcdh crops before wheat are fairly common.

10. Irrigated wheat ? rotated with varieties of garden crops/irrigated rice/rabi jowar.

MIXED CROPPING :

All over India, the growing of wheat mixed with barley, mustard, gram, lentil and safflower is quite common.

A row of mustard or safflower for every 8-12 rows of wheat is kept. This mixed cropping meets the farmers family requirement for cereals, pulses oil and also gives some insurance against pests, diseases and other natural calamities which may destroy the single crop.

In north western India and in the Tarai regions of UP, wheat is grown as a companion crop with row crops eg: scane.

About 3-4 tons of wheat is harvested as bonus in such companion cropping, without affecting the quality or yield of sugarcane.

Wheat based cropping Systems :

The introduction of dwarf Mexican wheat varieties have opened new dimensions with respect to its stability under various growing conditions. Thus, in turn, has made wheat a very common component of various cropping systems.

Wheat has made in roads into traditionally non-wheat growing provinces like WB, Assam, Orissa, AP, Karnataka and Maharashtra.

Traditional crop rotations are :

(Wheat belt of NI)

Maize-wheat-sorghum-wheat;

Pearlimillet-wheat.

The evolution of HYV's, short duration, photo & thermo insensitive varieties of rice, the availability of adequate production inputs and the margin of profitability have made Rice-wheat cropping an extensively practiced systems, both in traditional and non traditional rice/wheat areas.

Some common and promising sequences involving wheat are-

Maize-wheat-Prosomillet

Maize-wheat-Greengram

Prosomillet/maize-wheat-maize/cowpea is followed in areas having assured water supply in Gujarat, MP & Rajasthan.

Intercropped with barley, mustard, chickpea, lentil, safflower and linseed.

Mustard is a very common crop usually intercropped with wheat.

BY PRODUCT UTILISATION :

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

Export potential and economic importance

World wheat production is expected to set a new record of approximately 600 mt. The net import of wheat products by developing nations was 26 mt in 1995 of which Asian markets imported nearly 17 MT. During 1980's the rate of increase in wheat production actually declined in comparison to 1960's or 70's. Also the world wheat consumption exceeded the production in the 1980's which became a prime reason for non increase in Buffer stocks.

Annual production of wheat in India was 55 mt derived from cultivating 24 m ha area. Annual growth rate in wheat production was at 5.2% which has been comparatively high.

However, consumption demand for wheat and wheat products are expected to be about 76 mt by 2010, which is not an easy target to achieve. Relished by great majority of human population since several centuries, demand for wheat products may never cease in future.

Lecture No : 11

MAIZE

Botanical name : Zea mays

Maize- introduction- Origin- Distribution- Area- Production and productivity in India and AP- By products and economic importance- Classification of maize- Adaptation and climate.

IMPORTANCE

Maize is one of the important foods, green forage and industrial crops of the world.

It is called QUEEN OF THE CEREALS.

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.,

Corn oil is 4%

USES

Green ears find a ready market in the urban areas. The grain is ground into flour for making bread. Maize is being used as a poultry and cattle feed. Stover, whether green or dry is fed to the cattle.

QUALITY

Grain contains:

Protein- 10%

Oil – 4%

Carbohydrates – 70%

Fat – 5 to 7%

Fiber – 3 to 5%

Minerals – 2%

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, probably in the South western part of the Amazon river basin.

In its original home, the crop was developed by Red Indians from which it passed on to the European immigrants and then spread gradually all over the world. The crop has become so cosmopolitan that today in one area ore the other of the world, maize is being planted and cultivated practically every week of the year.

It was introduced into India by the East India company and has now spread to a very large areas of the country.

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.

1997-98

	World	India	AP
Area [mha]	140	6.30	396000ha.
Production[million tons]	420	10.85	1084000t
Productivity[kg/ha]	3000	1720	2740

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

In AP, it is intensively grown in North and South Telangana particularly Karimnagar, Medak, Nizamabad, Warangal and Adilabad districts.

ADAPTATAION 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 C_4 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 15^0 C. It cannot with stand frost at any stage of growth. Optimum temperatures for germination is 21^0C and for growth is 32^0C.

Min 9^0C ; optimum -32^0C
Max – 46^0C

In India, its cultivation extends from the hot arid plains of Rajasthan and Gujarat Extremely high temperature and high humidity during flowering damage the foliage, deissicates the pollen and interferes with proper pollination which results in poor grain formation.

600 mm rainfall with even distribution is sufficient for good cultivation.

Lecture No: 12

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

Best soils are --- Deept dark silt loams

In semi arid climates ---- Deep soils [heavy texture]

In sub humid climates --- Sandy loam soils.

Opt PH --- 6.5-7.5

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

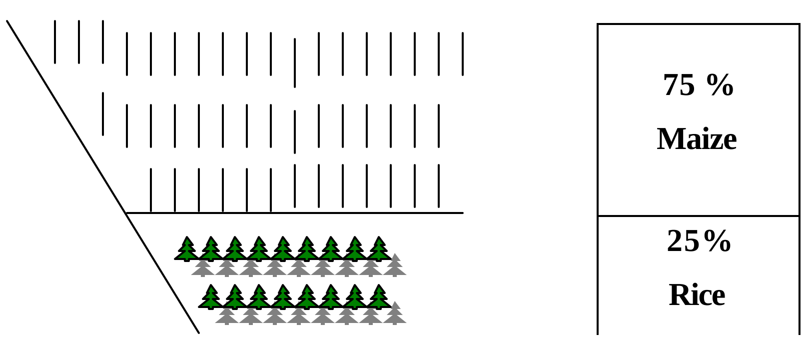
Crop--- Grown from Oct to January as irrigated one. Sowing maize at about 5 days before onset of monsoon [i.e last week of may to the second week of June] and providing irrigation, results in good plant stand and highest grain yields.

SEED BED PREPERATION [LAND PREPERATION]

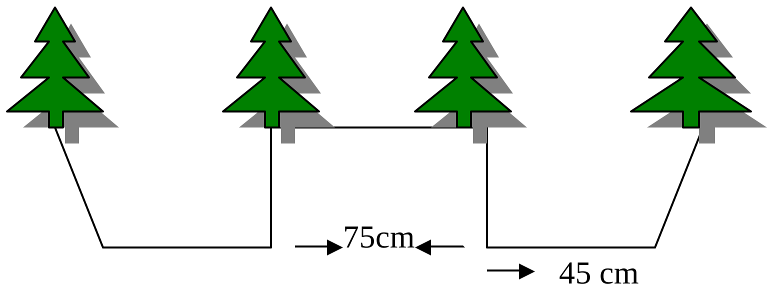
At least 2-3 shallow tillage operations during summer season are essential in all maize growing areas. Deep ploughing is also helpful to control weeds and for efficient moisture conservation similarly bed and furrow or ridge and furrow systems are suitable in semi arid and sub humid regions. In high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

ZINGG TERRACING

In this method, maize is grown in the upper 75/ area of the plot which is kept slopy to provide quick drainage and rice is grown in the remaining 25/ area which is leveled to accommodate the run off from the upper portion of the plant.



Another method of panting is double file planting where 50000 plants/ha can be accommodated.



VARIETIES : DHM-101, 103, 1 Rohini, Ashwini } synthetics

Trishulatha --- 3 way cross

Arsha & Varun ---- composites

SEEDS AND SOWING :

Yield of maize remains the same over a wide range of pant po;ulations. 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.

INTERCULTIVATION :

Weed contrl : 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, Echinoclhloa colonum

Sedges --- cyperus iria, eleusine indica

Cyperus rotundus

Firnbristilis miliacea

Brood leaved --- Celosisa argentina

Commelina bengalensis

Convolvulus

Tribulus terrestris

Solanum nigrum

Phyllanthus sps striga.

Maize needs two intercultivations and two handweedings.

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 pants 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.

CHEMICAL WEED CONTROL :

The first 6-7 weeks of maize growth is the most critical period for weeds. Depending upon the severity of weed infestation, the maize grain yield is reduced from 15 to even 100% The weeds growing in intra row spaces as well as near the base of the plant cannot be controlled by intercultivations because of the possibility of inflicting damage to the crop plants.

In view of the limitations of cultural methods of weed control, the combined use of herbicides and intercultivations is the most effective technique of weed control in maize. Pre emergence application of Simazine [Tafazine] or Atrazine [Atrafaf] at 2 kg/ha is found to control weeds effectively and it should be sprayed 2 or 3 DAs, wetting the entire surface uniformly. Later the soil should not be disturbed for 4-5 weeks after application of the herbicide.

For post emergence application of 2,4 DEE at 1 ½ -2 kg/ha at any time when maize is about 20 cm height.

Chemical control of weeds proves economical and effective during wet season, when timely cultural operations may not be possible.

WATER MANAGEMENT :

Maize is sensitive to both drought and water logging. Proper water management is a must for increasing yields. Maize uses water efficiently. It s water requirement is influenced by

1. growth stages
2. season
3. weather
4. Soil conditions

The optimum available soil moisture for maize crop is 80 or 75/.. The frequency of irrigation will be once in 6-10 days in a medium texture and average fertility soils depending upon rainfall.

The total water requirement vary from 530 mm to 800 mm depending upon the season and rainfall received during the crop growth period.

Light and frequent irrigations just to moisten the effective root zone of the maize crop viz., 15 cm to 22.5 cm depth of soil are more conducive to higher yield than heavy irrigations at long intervals being the total quantity of water remaining the same.

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/. 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 unfoll in the followring 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 selting 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 before 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 :

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.

Sl. No.	Type of soil	season	Stage	Method of appln.	Quantity to be apliv.
1	Light or sandy	K R S	i) sowing	Drill 10 cm away & 5 cm below the seed rows	¼ N
			ii) knee high (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 R	i) sowing	Drilling	¾ N
			ii) knee high	Broadcast & mix with soil	¼ N
			i) sowing	Drilling	¼ N
			ii) knee high	Broadcast and mix with soil	¾ N

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, filed has to be irrigated in case of irrigated crop.

In case of rainfed crop, it 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 so_4/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 $ZnSO_4$ not applied to soil fotiar spray of $ZnSO_4$ @ 5 kg + 2.5 kg lime/ha. Repeat 2-3 times at weekly intervals till the deficiency symptoms disappear. Basal application of $ZnSO_4$ 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.

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 fooder.

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

MAIZE AS FODDER : It is highly succulest which increases the milk yield of milch animals if combined with legumes. In AP, it is grown in "PYRU" season using seed rate of 60-70 kg/ha. Growth of maize in winter is more in South India compared to other crops. It is ready in 60-70 days. Harvest when the ears are in formation stage. Yield is 28-50 t/ha.

CLASSIFICATION OF MAIZE TYPES :

Flint corn is widely grown in India.

1. Dent corn (zea mays var identata 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. <u>Flint corn (Zea mays var indurate sturt)</u>

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. <u>Popcorn (Zea mays var verta sturt)</u>

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. <u>Flour corn ((Zea mays var anylacea sturt)</u>

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. <u>Sweet corn (Zea mays var Saceharata sturt)</u>

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. <u>Pod corn : (Zea mays var tunicate kulesh)</u>

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

7. <u>Waxy corn (Zea mays var ceratina Kulesh)</u>

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.

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.

By products and 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 swellsand 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.

Lecture No : 13

SORGHUM

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 grow n 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 quantitj.2S 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 5.5 million hectares with a production of 72 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.

IMPORTANT JOWAR GROWING STATES:

STATE	AREA (m.ha.)	PRODUCTION	PRODUCTIVITY
Maharashtr	5.5	3.8	-
AP	0.76	-	-
MP	0.90	-	0.83
Karnataka	1.90	1.6	0.86
UP	-	-	0.88

Gujarat, Tamilnadu and Rajasthan accounts for 90% of jowar area in India.

IN AP:	Area	:	760000 ha
	Production	:	552000 t
	Productivity	:	0.73 t/ha.

AP ranks third among the jowar growing states. This crop accounts for 19.9% of the total cropped area. It is largely grown in the districts of Mahboobnagar, Kurnool, Adilabad, Khammam .. Warangal, Nalgond.':l, Medak, Prakasam, Ananthpur, Karimnagar and Cucidapah.

The Telangana region contributes 64% of total sorghum cultivated area of the state; Rayalaseema : 21%; Coastal Andhra : 15%

Mahboobnagar district is highest in area and productior. Khammam is highest in productivity(757 kg/ha--1978 ..)

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 weII in heavy black soils. The best crops are grown the clay loams. Jowar does not grow well under gravely and marshy soils. The crop grows well in neutral pH of 7.0.

SEASONS OF AP : There are 4 seasons in an year viz., kharif, maghi, rabi and irrigated or summer

KHARIF : The kharif sowings are done in the month of june, july after the onset of southwest monsoon. Jowar is grown on light soils in this season (red &chalka) except parts of Adilabad where jowar is grown in black soils.

MAGHI : Sowings are done during the first fortnight of September, generally, delay beyond mid September is not desirable. Khammam district traditionally grows maghi or mid season jowar which is sown from late August to early September.

RABI : The rainfed rabi crop is generally sown in October after the cessation of SW monsoon. Those areas are generally confined to heavy black soils. Sowings are normally taken up in mid-October. Advancing the sowing date to 1st October is beneficial.

IRRIGATED OR SUMMER: During this period, the crop is grown as irrigated crop. The best period for sowing is during 2nd fortnight of January to 1st week of February. In black soil areas, where water is in sufficient for rice and other crops, jowar can be grown for which 1-5 irrigations are sufficient. The season could be utilized to produce good quality seed for kharif and rabi seasons.

MAJOR JOWAR GROWING ZONES

1.LOW RAINFALL KHARIF ZONE: The red soil area in the districts of Mahboohnagar, Nalgonda and Ananthpur. 500-750 mm rainfall with 75-175 days duration.

2 .. HIGH RAINFALL KHARIF ZONE: 800-1000mm rainfall. It consists of the districts of Adilabad, Karimnagar, Medak and parts of Rangareddy, Warangal, Guntur and Prakasam where sowings are done during 2nd week of july. Growing period is 190-230 days.

3.EARLY RABI OR MAGHI ZONE: 800-900 mm rainfall. 70:30 red and black soils. Contiguous areas of Khammam, Warangal, Nalgonda and Krishna.

4.NANDYAL VALLEY: 500mm rainfall. This zone includes the districts of KUrrlool and Cuddapah where sowings are done during 2nd fortnight of September. Black cotton soils.

5.NORMAL RABI ZONE: Light to heavy black cotton soiis. Parts of Adilabad, Rangareddy, Karimnagar, Medak, Mahboobnagar, Nizamabad and Guntur districts. Normal sowing jJeriod is 1st fortnight of October.

6 . LATE RABI ZONE: The districts of Nellore and adjoining areas of Prakasam constitute this zone which comes under the influence of NE monsoon.

MAIN FIELD PREPERATION: 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 h3rrow. 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.

Incase of irrigated crop, aft'=r 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.
Incase 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-l0m apart across ridges and furrows to adopt turrow 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 ares for the USE of jowar crop
6.Providing drainage i'1 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 his tillag/2 and seeding equipment using bullock power "a year round tillage programme" was developed at AICRIDA, Hyderabad.

The year round tillage has several advantages:
l.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, it 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 (GS_1, GS_2 and GS_3) and are described as follows (Vanderlip and Eastin)

GS_1 (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.

$G5_3$ (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.

RELATIONSHIP BETWEEN YIELD ATTRIBUTING CHARACTERS AND GROWTH STAGES

Number of grains produced and number of fertile grains will be mostly decided at 2^{nd} growth stage i.e from PI to flowering ($G5_2$) •

Test weight or weight of individual grains will be based on the function of the plant in the physiological maturity stage (Le. $G5_3$)

AFTERCULTIVATION : Jowar is a warm season crop. The environmental conditions which favour the germination and growth of jowar are also favourable for luxuriant weed growth. Sorghum seedlings are weak and make a slow growth during the initial stages upto 40-45 days. Effective weed control during this stage is inevitable.

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

Lecture No : 14

SEEDS AND SOWING

Sorghum is sown by various methods in different parts of the country. The methods are l.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 12-18kgjha. 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 8-12kgjha. 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 Le. 6kgjha and gives the equal opportunity to all plants for their grow 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 i1re 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 Iines 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 m-ale 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 re growth of stubbles of previous main crop after its harvest, there by avoiding reseeding or replanting such as sugarcane, sorghum, rice, fodder grasses etc.,

Hybrids of sorghum can, be ratooned with good success. They give even 'l1ore yields to the main crop if they are properly managed. Of all CSH-l 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 4/1 to 6/1 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; Y2 to be applied at the bas(! of the stubbles and covered before the 1st irrigation and the 2nd Y2 of N at 30 days after from date of rationing.

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 putforths 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 fie ld have to be harvested at one time.

9. Ratooning reduces expenditure on land preparation, sowing, fertyilisers 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 organ omercurial compounds or carbomates @ 2.5g/kg seed.

For shoot fly-carbofuran 50wp@ 100g/kg seed.

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 10eClI varieties, in many cases 25kg N+ 25 kg P20s/ha gave higher yields compared to 50kg N/ha under dry land conditions. Under irrigated conditions the doses of N & Pare 40 kg/ha each

DOSES FOR HIGH YIELDING VARIETIES

	Irrigated	Rainfed
N (kg/ha)	100-120	80
P	60	40

K " not essential but in deficient soils apply on the basis of soil analysis.

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 & P20S 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 FERTILISERMANAGEMEl\IT

1. Jowar crop removes large quantity of nutrients from soil.
2. Growth and nutrient uptake will be more rapid after 40 days from ~owing. 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 yields.
5. Use the 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 (50-55DAS)
4. Flowering (70-75 DAS)
5. Grain formation stage (100-105DAS)

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.

I

Peak water requirements are at boot to flowering and early grain development stages i.e 25^{th}, 45^{th} and 55^{th} 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 presowing 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.
b. 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.

WEED CONTROL : 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. lnterculturing 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 sps of striga are l.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 sps 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 2,4-0 @ 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 THRESHIING: 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 cur 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.

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

MID SEASON CORRECTION: The practices that are adopted when crop is subjected to prolonged drought/ aberrant weather conditions in order to mitigate the adverse effects caused due to them are known as mid season corrections. They are 1. Ratooning 2. Thinning the plant population 3. Removing the crop which is more sensitive to moisture stress in mixed cropping (eg: jowar + safflower) 4. Follar spray (eg: groundnut) with nutrients are some of the mid season corrections.

At Bellary , with a limited moisture, jowar plants are earless when the population is 80000/ha. But when the population was reduced to 20000/ha ear emergence and grain setting is satisfactory.

In a crop mixture of jowar- safflower (during rabi in black soils), remove jowar which is sensitive to moisture stress and allow safflower to grow alone.

Ratooning can be done with jowar and bajra crops with the receipt of rains after a prolonged dry spell. Urea can be sprayed on crop foliage (eg : groundnut) after the receipt of rains soon after a prolonged dry spell.

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

Sorghvn - Tobacco

Sorghum – Finger millet - Groundnut

Groundnut - Rabi sorghum

(ii) Mixed cropping (kharif)

Sorghum+pigeonpea

Sorghum+greengram

Sorghum+blackgram

Sorghurn+cowpea

Mixed cropping(rabi)

Sorghurn+safflower/ sunflower

The average grain composition of sorghum grain is as follows:

Protein : 7.4 – 14.2%

Lipids : 2.4 – 6.5%

Carbohydrates : 70 – 90%

Fibre : 1.2 – 3.5%

Minerals (mg/100gm)

Ca : 11 – 586

P : 167 – 751

Fe : 0.9 – 20.0

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 amyloprotein 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.)

Lecture No: 15

BAJRA

(*Pennisetum americanum)*

English: Pearlmillet Telugu: Sajja

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 poorman'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

12.4% moisture

11.6% protien

5.0% fat

67% carbohydrates &

2.7% minerals

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

Rank	Area	Production	Productivity
I	Rajasthan	Rajasthan	M.P
II	Maharastra	Gujarat	Haryana
III	Gujarat	Maharastra	Gujarat

In A.P. Bajra is mainly grown in Srikakulam Vizanagaram, Visakhapatnam, Ranga Reddy, Mahboobnagar, Nalgonda, Prakasam, Chittoor and Anantpur districts .

Rank	Area	Production	Productivity
I	Visakhapatnam (36,900 ha)	Prakasam (34,000t)	Nellore (1658 kg/ha)
II	Prakasam (29,300 ha)	Visakhapatnam (28,300t)	Cuddapa (1605 kg/ha)
III	Nalgonda (25,900 ha)	Kurnool (12,200t)	Srikakulam (1324 Kylha)

ADAPTATION:

The crop has wide adaptability as it may grow under different day lengths, temper atures and moisture stress. It has a high degree of resistance for drought. Most of the varieties developed in India are photo-insensitive which permits in growing the crop during Kharif, *rabi* and summer seasons. The crop requires low annual rainfall ranging between 40 to 50 cm and dry weather. The crop needs wet weather, light showers and bright sunshine, at its grand growth stage. There should be no rain at flowerns as the pollens are washed off and fertilization is found to be poor, while at maturity it needs fairly dry weather associated with bright sunny days. The crop may tolerate drought but cannot withstand high rainfall of 900mm or above. The best temperature for the growth and development of bajra is between 30^{o}c and 35^{o}c.

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.

Meththod 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 to60 -30 -20 kg N, P_2O_5, K_2O/ha

Irrigated : 100 to 120 - 40 -20 kg N, P_2O_5, K_2O/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 wedding, 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.

YIELD ATTRIBUTES:

Total number of tillers per unit area

Number of productive tillers per unit area

Lenth of the earhead

Number of filled grains per earhead

Test weight

YIELD:

Rainfed: Grain : 12-15 q/ha

Dry stover : 70-75 q/ha

Irrigated: Grain : 30-35 q/ha

Dry stover: 100 q/ha

CROPPING SYSTEMS:

Sequential cropping: Pearlmillet- Ground nut

Pearlmillet - Cowpea

Pearlmillet- Pigeonpea

Pearlmillet – Barley

Pearlmillet- Wheat

Pearlmillet- toria

Inter cropping system :Pearlmillet + Groundnut

Pearlmillet + Cowpea

Pearlmillet + Pigeonpea

Pearlmillet + Castor

Pearlmillet + Sesame

Pearlmillet + Mungbean

Pearlmillet + 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

Lecture No: 16

FINGERMILLET (*Eleusine coracana*)

English name :	**Telugu**
Finger millet	*Ragulu*
Birds foot millet	*Taidalu*
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 with out wastage.
- Besides vitamin A&B phosphorus is also present in smaller quantities.
- The grain is nutritionally rich and the richest in 'calcium'

NUTRITIONAL STATUS

Proteins - 9.2%

Fat - 1.29%

Carbohydrates - 76.32%

Minerals - 2.24%

Ash - 3.90%

Calcium - 0.33%

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 form India to Abyssinia and rest of Africa.

Mehra (1962)

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.

	Area	Production	Productivity
I	Karnataka	Karnataka	Tamil Nadu
II	Vizag	Vizag	Prakasam
III	Chittoor	Vijayanagaram	Guntur
IV	Vijayanagaram	Ananthapur	Ananthapur

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 50^0 to 100^0 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.

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.

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 Visakhapantam. 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.

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 tyned 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: 4-6 kg/ha.

SPACING:

15x15 cm or 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, P_2O_5 and K_2O/ha

For mainfield: FYM: 10t/ha – Before sowing

60-30-30 kg N, P_2O_5 and K_2O/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 THRESHIN G:

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.

YIELD ATTRIBUTES:

Number of plants per unit area

Number of tillers per unit area

Number productive tillers per unit area

Number of fingers per earhead

Number of filled grains per earhead

Test weight

YIELD

Rainfed: 7- 8 q/ha - grain

11-18 q/ha – fodder

Irrigated: 30-35 q/ha - grain

35-50 q/ha – fodder,

Varieties:

Kalyani – Released in 1971 from ARS, Pelumallaplle

Sarada - Relesed in 1972 in 1971 RARS, Anakapalli.

Godavari - Released in 1974 - ARS, Peddapuram

Simhadri - Released in 1981 – ARS Vijayanagaram

Ratnagiri - Released in 1985 – ARS, Peddapuram

Hamsa, co-9 – White grained var. with protein (12%) others (7.9%)

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, pearlmillet 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

Lecture No: 17

KORRA (*Setaria Italica*)

English Names: Italian millet

Fox tail millet

German millet.

It is grown in many of the Asian, African and American countries especially where the climatic hazards do not permit the cultivation of other cereals. It is generally grown as a rainfed crop in india.The grains are cooked like rice and then utilized. In some areas the grains are ground to flour and used in the form of chapaties.

Korra grains contains

12.3 %	- protein
4.7%	- fat
60.6%	- carbohydrates
3.2%	- Ash

The grains are fed to cage birds. The straw is thin stemmed and is liked by cattle. It is not good for horses. In China, Italian millet is next to rice and wheat in importance. It provides approximately 15-17% of the total food consumed in china.

ORIGIN

It is a very old crop. It was cultivated in China as early as 2700 B.C. Vavilov (1935) considered China as its place of origin. Werth considers China (or) Central Asia as its place of origin. According to him setaria spread to india and Europian countries from there.

Distribution:

Setaria is cultivated in China, Korea, Japan, Afghanistan, Syria, S.Africa and India & to some extent in Africa and American countries. China still ranks first in foxtail millet production in the world (4.6mt) where as world production is 6mt.

The area under foxtail millet in India has comedown by more than half during 1990's mainly due to introduction of more remunerative crops like sunflower & soybean in blacksoils. However, it is still grown to meet the domestic needs of the rural people.

In india, it is cultivated in Karnataka, A.P, M.P and U.P. In A.P. Korra is suitable for dryland cultivation in Anantapur, Kurnool, Prakasam, Mahaboob Nagar, Guntur and Rangareddy Districts. In A.P. it occupies an area of 1.74 lakh ha. with a total production of 0.85 lakh tonnes / annum.

SOILS

Setaria requires fairly fertile soils for good yields, although it can grow in poor soils. Light soils including red loams, alluvials and black cotton soils are suitable for its cultivation. But it thrives best in rich, well drained loam soils.

LAND PREPARATION:

It does not require much field preparation, Before the onset of monsoon the field should be ploughed once with mould board plough. With the onset of monsoon the field should be harrowed or ploughed with local plough twice. Planking should be done for making the field smooth and well levelled.

CLIMATIC REQUREMENTS:

Setaria is cultivated in tropical as well as temperate regions. The crop can be grown even at an altitude of 200mts. It requires moderate temperature throughout its life cycle. The crop can be grown successfully in areas receiving 50-75 cm annual rainfall. Although its water requirement is low, the plant has no capacity to recover after a long spell of drought.

SEASONS:

It is grown through out the year from early rainy season

Early rain season (May)

Monsoon Season (June- July)

Late Season (Aug-Sept)

Irrigated (or) Summer season (Feb-Mar)

Seeds & Sowings:

Seed rate: 5 kg /ha

Spacing: 30x10 cm

The seed can be sown with local seed drill with tynes 30cm, apart. Covering of the seeds with blade harrow is recommended

MANURES AND FERTILIZERS:

The crop is usually manured with 10-12t of FYM per hectare. To get a good crop, 40 Kg N, 30Kg P_2O_5 and 20 Kg K_20 / ha is sufficient. All the fertilizers should be applied as basal dose at the time of sowing. If irrigation is available apply only ½ of the dose of N and full amount of phosphorus and potash at the time of sowing and remaining ½ quantity of N at 30 DAS.

IRRIGATION:

Setaria sown during *kharif* season, does not require any irrigation. How ever, if dry spell prevails for longer period, then 1 or 2 irrigations may be given to boost yields. Summer crop requires 2-5 irrigations depending upon soil type and climatic conditions. During rainy season, drainage is essential. Remove excess rain water from the field as it does not withstand water logged conditions.

INTERCULTIVATION:

Keep the field free from weeds. Intercultivation should be done with a tyne-harrow when the crop is 30 days old.

MIXED CROPPING:

Korra – Cotton mixture is of repute in Rayalaseema. It is also mixed with Ragi, Jowar, Bajra, Redgram, Costor and pulses.

HARVESTING AND THERESHING:

The crop flowers in 50-60 days and matured in 80-100 days. The crop is harvested when the earheads are dry either by cutting the whole plant by sickle or the ears separately. After drying for few days threshing is done with a stone roller or by trampling under the feet of bullocks.

CROPPING SYSTEMS:

Fox tail millet is grown as sole crop, subsidiary crop mixed with finger millet as in Karnataka or to a large extent as mixed or inter crop with cotton. When it is grown as a sole crop under dry land conditions, it is usually followed by sorghum, finger millet or pearl millet in the next year. Inter cropping of foxtail millet and cotton is usually followed by sorghum in the next year.

Inter cropping: Foxtail millet + pigeon pea (6:1)

Foxtail millet + Bengalgram

Foxtail millet + Safflower

Foxtail millet + Sunflower

Foxtail millet + Rice

Foxtail millet + Groundnut

YIELD ATTRIBUTES:

Number of plants per unit area

Total number of tillers per unit area

Number of productive tillers per unit area

Length of the panicle

Number of filled grains per panicle

Test weight

YIELD:

Rainfed crop :	Grain – 6 -10 q/ha
	Straw – 10- 20 q/ha
Irrigated crop :	Grain – 10- 16 q/ha
	Straw – 20- 40 q/ha.

VARIETIES: Chitra, Arjuna, Prasad, Lepakshi, Krishnadevaraya, Nallamala, Narasimharaya, Srilakshmi etc.

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ARIKA (*Paspalum scrobiculatum*)

Or

KODO MILLET

Kodomillet is a highly drought resistant crop. It is the coarsest of all the food grains. The grain is covered with a horny seed coat which should be removed before cooking. Immature and molded grains are supposed to be poisonous. Kodo grain is easily preserved and proves as a good famine reserve. The grain is recommended as a substitute for rice to patients suffering from diabetes disease. The grain contains.

8.3% protein

1.4% fat

65.6% carbohydrates

2.9% Ash.

Straw is very poor in quality and 'harmful' to horses. Some of its species are used for pasture & forage and to check soil erosion due to their binding capacity

ORIGIN:

Kodomillet (Arika) is a very old crop .There is a mention of Arika in ancient literature of India. Some of the investigators think that Arika probably originated in South-East Asia.

DISTRIBUTION:

Arika is grown mostly in A.P., Maharastra, Karnataka, Tamilnadu and U.P.

SOILS:

Kodo is grown from gravelly and stony upland poor soils to loam soils. Inspite of adverse conditions the crop can struggle on even poor soils and may yield some quantity of grain and straw. But it thrives best on sandy loam to loam soils. Soil should be well drained.

CLIMATIC REQUIREMENTS:

It makes a rapid growth in warm and dry climate. It is highly drought tolerant and, therefore, can be grown in areas where rainfall is scanty and erratic. It grows well in areas receiving only 40^0 to 50^0 mm annual rainfall.

LAND PREPARATION:

Before the onset of monsoon, the field should be ploughed to get good tilth and enable it to retain moisture. With the onset of monsoon field should be harrowed or ploughed with local plough 2-3 times followed by planking. Field should be levelled.

SEASONS, SEED AND SOWING:

Sowing time of Arika is between June 15^{th} – July 15^{th} in northern India. In South, it is mostly grown as rainfed crop from September to December.

Seed rate – 10- 12 kg/ha

Spacing - 30 x 10 cm

Depth of sowing – 3- 4 cm

Method of sowing – Broadcasting, Drilling

MANURES AND FERTILIZERS:

Addition of organic manures is always beneficial since it helps to improve the water retention capacity of soil in addition to providing essential nutrients to the crop plants. The crop should be manured with 5-10t of 40-20-20 FYM/ha. Apply 40 kg Nitrogen, 20 Kg P_2O_5 and 20 Kg K_2O/ha in the form of chemical fertilizers. All the fertilizers may be applied at the time of sowing in furrows.

IRRIGATION:

Kodo sown in *kharif* season generally does not require any irrigation. It is mostly grown as a rainfed crop. If irrigation facilities exist, apply one or two irrigations at the time when rains stop for a long spell. Drain out the excess rain water from the field during heavy and continuous rains.

WEED CONTROL:

It is essential to control weeds in the initial stages of plant growth. Field should remain weed-free upto 35-40 DAS. Generally two weedings at an interval of 15 days are sufficient. Weeding may be done with hand hoe or wheel hoe in line sown crop.

HARVESTING and THRESHING:

The crop become ready for harvest in the month of September or October in northern India. The plants are cut close to the ground, bundled and stacked for a week and then threshed by trampling under the feet of bullocks.

CROPPING SYSTEMS:

In addition to solid stands, most small millets are are also grown as mixed crop with cotton, maize, sorghum,pigeon pea, and other pulses. Since, small millets are generally grown on marginal lands, *kharif* season millets are followed by rape seed-mustard, gram, lentil, linseed, barley, etc.,the *rabi* crops are grown under rainfed conditions.

YIELD ATTRIBUTES:

Number of plants per unit area

Total number of tillers per unit area

Number of productive tillers per unit area

Length of the panicle

Number of filled grains per panicle

Test weight

YIELD:

Grain : 8-16 q/ha

Fodder : 15-40 q/ha

Grains should be stored after drying them properly. Moisture in grain should not be more than 10-12%.

VARIETIES: Niwas-1, Dindori-73, Pali, JK- 76 & 62, JK-2, GPUK-3, APK-1, KMV-20

Lecture No: 18

VARIGA (*Panicum miliaceum*)

Also called as Proso millet or Common millet

This is an important minor millet grown in India. The crop is able to evade drought by its quick maturity. Being a short duration crop (80-90 days) with relatively low water requirement, it escapes drought and, therefore, offers better prospects for intensive cultivation in dry land areas. Where irrigation facilities are available, this is profitably grown as summer catch crop in high intensity rotations. It is quick growing grain crop, often grown during emergencies, famines or when sowings of other crops is abnormally delayed.

Nutritive values:

12.5% Proteins

1.1% Fat

68.9% Carbohydrates

2.2% Crude fibre

3.4% Ash.

Vargia contains lysine as high as 4.6% of protein. Grains are cooked like rice, flour is used for making "Chapaties". It can be used in making 'Kheer'. It is a good poultry feed. Straw is good fodder for cattle.

ORIGIN:

Variga probably originated in India. It spread from India to other parts of the world. It might have originated from ***Panicum psilopodium*** which is found in its wild state in Mynamar, India and Malaysia.

AREA & DISTRIBUTION:

It is grown extensively in India, Japan, China, Egypt, Bihar, Tamilnadu, Maharastra, Andhra Pradesh and Karnataka.

In A.P. it is grown in Guntur, Prakasam, Nellore, Cuddapah and Kurnool Districts. In A.P it is grown in an area of 44,000 ha with an annual production of 25,000 tonnes.

CLIMATE REQUIREMENTS:

Variga is a crop of warm climate. It is highly drought resistant and can be grown in areas where there is scanty rainfall. It can withstand water stagnation also to some extent.

SOILS:

It can be grown both in rich and poor soils, having variable texture, ranging between sandy loams to clays of black cotton soils. Coarse sands are not suited for its cultivation. Well drained loam or sandy loam soils rich in organic matter are ideal for variga cultivation.

LAND PREPARATION:

Soon after harvesting of previous crop, the field should be ploughed to expose the soil to sun and enable it to retain more moisture.

With the onset of monsoon, the land should be harrowed 2-3 times and then finally levelled.

SEASONS:

As a *kharif* crop, variga should be sown in the first fort night of July with the onset of monsoon rains. As a summer crop it should be sown by the middle of April.

SEEDS AND SOWINGS:

Variga can be sown by broadcasting or by drilling the seeds in furrows 3-4 cm deep.

Seed rate : 8-10 kg/ha

Spacing : 30 x 10 cm

MANURES & FERTILIZERS:

Variga being a short duration crop, requires relatively less amount of nutrients compared to other cereals. If organic manure is available, it may be added to the soil about a month before sowing @ 5-10 t/ha.

To get a good crop, general fertilizer recommendations under irrigated conditions are 40 kg nitrogen, 30 kg P_2O_5 and 20 kg K_2O/ha.

Apply half of the nitrogen and whole of phosphorus and potash as a basal dose at the time of sowing. The remaining half of the nitrogen should be applied at the time of first irrigation. Under rainfed conditions, fertilizer dose is reduced to half of the irrigated crop.

IRRIGATION:

Variga sown during *kharif* season, generally does not require any irrigation. However, at tillering stage, if dry spell prevails for longer period, then one irrigation must be given to boost yields.

Summer crop however would require 2-4 irrigations depending upon soil type and climatic conditions. Give first irrigation 25-30 days after sowing and second irrigation about 40-45DAS. Due to shallow root system of Variga, heavy irrigation is not advisable.

INTER CULTIVATION:

For getting high yield and minimizing loss of soil moisture and nutrients, the field should be kept weed free upto 35 days stage. Two weedings at an interval of 15-20 days would help control it. Weeding may be done with handhoe or wheel hoe.

HARVESTING AND THRESHING:

Variga is ready for harvest after 65-75 days after sowing in most of the varieties. The crop should be harvested when about 2/3 rds of seeds are ripe. Crop is threshed with hand or bullocks.

YIELD:

Rainfed crop : Grain - 4- 8 q.ha.

Irrigated crop : Grain – 10-20 q/ha

Straw yield varies from: 10-25 q/ha.

Under improved conditions: Grain – 20-25 q/ha.

Straw – 50-60 q/ha.

VARIETIES:

S.No.	Variety	Season	Duration (Days)	Yield (q/ha)	Characters
1.	Varada 1971, ARS, Podalakur	Rabi	80	16-20	Withstands moisture stress, suitable for all, variga growing areas.
2.	Nagarjuna, 1988 (RARS, LAM)	Rabi	65	20	,,
3.	Sagar, 1988, RARS, LAM	Rabi	80	22	,,
4.	V-27 ARS Podalkur	Rabi	80	17	Guntur, Prakasam,
5.	PV-38, ARS, Podakur	Rabi	80	20	Nellore
6	Manasa	Rabi	80-85	24	Tolerant to moisture stress

SAMA or Little Millet

Panicum sumatrence (*Panicum millare*)

As the name little millet indicates it is a crop of minor significance. It grows on the soils which are unsuitable for other crops. In Hindi Little millet is known as 'Kutka'. Like most millets, it is also a good famine food as it can produce some grain under drought conditions when all the other crops fail to produce. It has a potential as fodder crop as it has been reported that some of the little millet types mature in about 45-50 days. The husked grain of this millet is cooked almost in a manner similar to rice or rotis can be prepared with this flour.

- Little millet is grown on a limited scale.
- It is known as Poorman's crop.
- It is capable of with standing both drought and water logging.

DISTRIBUTION:

It is a grown in India and Srilanka. It India it is grown in Tamilnadu, Andhra Pradesh, Madhyapradesh and Uttarpradesh. It is confined to poor and upland soils in small patches in Kurnool, Anantapur, Guntur, Mahaboobnagar, Cuddapah, Chittoor, Vizag and Srikakulam Districts.

ADAPTATION:

It can thrive upto 7000 feet above. It is a typical dryland crop, suited to low rainfall and poor soils.

Duration:

It flowers in 40-75 days and matured in 80-110 days.

Season:

July – October

Land Preparation:

It requires minimum tillage. It is not regularly manured. Sometimes no after cultivation is done.

Sowing:

seedrate 4- 6 Kg/ha. Sown by means of Broadcasting.

YIELD ATTRIBUTES:

Number of plants per unit area

Total number of tillers per unit area

Number of productive tillers per unit area

Length of the panicle

Number of filled grains per panicle

Test weight

Yield : Grain: 4- 5 q/ha.

Straw : 10q/ha

Straw is soft, fed to animals. Used to stuffing saddles of horses and coarse mattresses

Varieties: Paiyur-1,Paiyur-2, Co-3, PM-2, PM-296, Dindori-1. .

UNIQUE CHARACTERS OF MINOR MILLETS

1. Wider adaptability
2. Short duration
3. Resistance to pests and diseases
4. High W.U.E.
5. Resistance to drought and variations in the climatic abnormalities.
6. Wide range of Photoperiodism
7. Higher nutritional values.
8. Less potential to yield.
9. Long shelf life.

FACTORS INFLUENCING LOW CONSUMPTION

- Lack of regular supply of small millets largely due to limited demand by urban population.
- Availability of cheap preferred cereals such as wheat & rice
- Higher social prestige associated with consumption rice & wheat.
- Marketing channels are not well developed for small millets due to distance between remote producing areas and major consuming centres.
- Most food aid projects include other cereals, more readily available in the market, rather than small millets.
- Increased production though higher yields has led to decrease in area under small millets in favour of cash crops

The ICAR in New Delhi established the following 6 crop specific lead centres with the help of the International Development centre, Canada in 1978-79 for the improvement of small millets.

1. For Ragi – Bangalore.
2. For Prosomillet at Dholi in Bihar
3. For Kodomillet at Dindori in Madhyapradesh.
4. For Foxtail millet at Nandyal in Andhra Pradesh.
5. For Little millet at Semiliguda in Orissa.
6. For Barnyard millet at Almora in Uttar Pradesh.

LECTURE No. 19

CROP PRODUCTION-I

COURSE No. AGRO 203

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.

a) NPDP : National Pulse Development Programme.

b) SFPP : Special Food grain Production Programme.

⇒ Per capita requirement of Pulses :

⇒ Per capita requirement of Pulses: Acc. To ICMR – 150gm /dayand Acc. To FAO – 140gm /day

⇒ At present, the per capita availability of pulses in India is only 47gm/day

AREA, PRODUCTION AND PRODUCTIVITY OF PULSES IN INDIA

Pulses are grown over an area of 23 miilion ha with a production of 13 to 14 million tonnes with average productivity levels ranging from 500-600 Kg/ha.

⇒ India accounts for 33% of total world area under pulses and 25% of total world production.

⇒ Kharif pulses (Pigeon pea, black gram, green gram, horsegram, Mothbean, Cowpea) cover 45% of total area and 30% of total pulse production.

- ⇒ Rabi pulses (Chick pea, pea, lentil, lathyrus) cover 55% of total area and 64% of production
- ⇒ In Andhra Pradesh area under pulses is 14.7 lakh ha with a production of 5.75 lakh tones and the average productivity is only 390 kg/ha.
- ⇒ Major pulse producing states are Madhya Pradesh, Maharastra, Orissa, Rajasthan and Uttar Pradesh.
- ⇒ Highest production of pulses is from Madhya Pradesh followed by Rajasthan and Uttar Pradesh.
- ⇒ Haryana has the highest productivity (880 kg/ha)
- ⇒ National average productivity is 570 kg/ha

AREA , PRODUCTION AND PRODUCTIVITY OF PULSES IN INDIA

SL.NO	STATE	AREA (Ha)	PRODUCTION (T)	PRODUCTIVITY (Kg /Ha)
1	Andhra Pradesh	1470	575	390
2	Assam	118	64	55
3	Gujarat	895	613	680
4	Haryana	422	375	**890**
5	Madhya Pradesh	**5029**	**3254**	650
6	Maharastra	3267	1243	350
7	Punjab	87	60	680
8	Rajasthan	4389	2635	600
9	Uttar Pradesh	2808	2318	830

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 smoothering crops which control weeds & protects soil from erosion E.g.:- Cowpea and Horse gram. Pulses can also be used better intercrops.

<u>Lecture No. 20.</u>

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. Over the past 3 decades, the area production and productivity of pulses have been swinging between 22 to 24 million hectares, 10-14 million tonnes and 475-544 Kg/ha, respectively. As a result, their availability has declined sharply from 64 gm per capita per day during 1951-56 to less than 40 grams per capita per day during 1987-88 as against FAO/WHO's recommendation of 80 gm/capita per day. 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.

AGRONOMIC CONSTRAINTS:

i) <u>Improper sowing time</u>: 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 sowing 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) <u>Low seed rate</u>: 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) <u>Defective method of sowing</u>: 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 greengram and blackgram and as high as 90% in pigeonpea 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 leafspot diseases in greengram, blackgram 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 flewering/fruiting

⇒ 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 redgram 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 Greengram and Blackgram 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 Blackgram and Green gram. The rice fallow pulses are grown with the available residual soil moisture and residual fertility.

Beofre 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.

Generally ferilisers and irrigation are not given and hence farmers mostly preferred as economical crop

The seed rate for Blackgram : 40- 45 kg/ha

Varieties recommended are LBG 645, LBG 648 LBG 685, and LBG 752

The seed rate for Greengram : 30 -35 kg/ha

Varieties recommended are LGG 460,LGG 410, TM 96-2

Constraints:

- Maintaining optimum plant population is one of the major constraint in rice fallows as the seed is sown in the standing paddy crop.
- Possibility of waterlogging at initial stage of establishment due to sudden rains or lack of proper drainage before sowing.
- As the crop is sown in rabi, there is possibility of terminal moisture stress especially for Blackgram.The terminal moisture stress is much more pronounced in case of sandy soils rather than Blacksoils.
- Powdery mildew infection may be observed initially during vegetative stage.
- The final yield of rice fallow pulses are lesser than that of direct sown pulses.

Lecture No. 21

REDGRAM

Scientific name - Cajanus Cajan

Common Names - Arhar, tur, redgram, congo pea, Gungopea, 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.

* Pigeonpea ranks sixth in area and production in comparison to other pulses.

PLACE	AREA	PRODUCTION	PRODUCTIVITY
India	3.61 Mi.ha	2.7 Mi.tonnes	747 kg/ha
A.P.	2.43 lakh ha	0.57 lakh tons	235 kg/ha.

VARIETAL IMPROVEMENT

Long duration - 180-270 days

Medium duration - 150-180 days

Early duration - 120-150 days

Extra early duration- <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 the promising variety both in kharif and Rabi, ICPL 85063 (Lakhsmi) 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.

SOILS: 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^{o}N & 35^{o}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.
-

SEEDS & SOWING:

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.
5. 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 P_2O_5/ha for phosphorous deficient soils at sowing.

POTASSIUM: 20kg K_2O/ha for potassium deficient soils by placement at sowing.

IN A.P, 20N & 50 P_2O_5 in addition to 5t/ha FYM for Kharif crop. For rabi crop, Nitrogen dose is doubled (40N kg/ha).

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:

- **YIELD ATTRIBUTES;** The Redgram is said to be indeterminate in growth habit where the flowering goes on continuously over the months on the same plant. Flowering, unriped 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 unriped 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 .
- Plant population/unit area
- Plant height
- No. of pods/plants:

YIELD: For irrigated – 15-18 qt/ha

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 No. 22

BLACKGRAM or (Urd bean)

Vigna mungo (Linn.) Hepper

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 muscilagenous 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^{o}C but it can tolerate upto 42^{o}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.

In A.P:

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 :UG-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 and sowing:

Seed rate Kharif – 15-18 kg/ha.

Rabi - 18-20 kg/ha

Rice follow - 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 P_2O_5/ha

Irrigated : 25 kg N + 50 kg P_2O_5/ha.

Foliar spray of DAP and NAA (rice follows)

- 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 follows: 500 kg/ha.

Processing:

1. Dal milling: Dal milling is one of the major food processing industry and a 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 No. 23

GREENGRAM

Botanical Name: Vigna radiata

Family : Leguminasae

Common Indian Name: Mung

(or) Mung bean

(or) goldengram

- 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 it's shorter duration, it can be fitt 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, Pakisthan, Thailand, Srilanka, Indonesia and China are the principal countries of greengram cultivation.

Area, production and productivity:

	Area	Production	Productivity
India	3 million ha.	1.2 million tonnes	436 kg/ha
A.P.	6 lakh ha	2.5 lakh tonnes	350 kg/ha.

In A.P. the crop is mainly cultivated in Warangal, Karimnagar, Krishna, Khammam, Adilabad, Nalgonda, Guntur and Nizamabad districts where Rainfall is less than 600mm in Kharif.Area and production of greengram is highest in Orissa whereas highest productivity is recorded in Punjab.

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 40^0C, 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 horrowing 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 broad casted 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

Optimum seed depth for sowing ---- 5-7cm

Spacing: 30X10 cm

Plant population: 3.33 Lakh plants/ha

VARIETIES:

AICRP Centre: RARS, Lam

Non-Plan Centre: ARS, Madira

Varieties released from A.P

11 Varieties

LGG-127,407,450,410,460,

TM 46-2, WGG 2, WGG 37,

MGG 295, MGG 347,MGG 348.

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),

OVM 11-5, CoGG 912

First mung variety released in Orissa during 1980: Dhuli

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

Resistant Varieties:-

Yellow Mosaic virus --- LGG 407,LGG 460,WGG 2,WGG 37,PDM 54,ML 267,

Leaf Curl --- LGG 460, MGG 295

Angular Black Leaf Spot –-- LGG 407, WGG 2

Powdery Mildew --- TM 96-2, TARM 18.

Seasons:

1) Kharif Greengram
2) Summer Greengram and
3) Rabi Greengram
4) Summer Mung: is advantageous because

Quick maturity (60-65 days)

Low pest and disease incidence

Utilizes residue fertility of previous crops

FERTILISERS:-

Rhizobium inoculations considerably minimize the need for nitrogen fertilizer application.

Rainfed Crop: 10 kgN/ha (Starter dose (or) booster dose) & 30 $P2O_5$ Kg/ha (Basal)

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

Nearly 40N, 10P_2O_5 & 15 K_20 Kg/ha is removed by 1 tonne of Greengram.

Biofertilizers:

For Mung bewan, 500 gr of Rhizobium culture is sufficient for seeds required to be sown in 1 ha i.e., 2.5 packets/ha

(Since I packet=200 gr)

Greengram fixes 20 Kg N/ha

Greengram associated with VAM (Vesicular Arbuscular Mycorrhiza)

Which is a PO^{-3}_4 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:
4. .Susceptable to diseases: Major diseases and pests are: Yellow Mosaic Virus, Leaf Curl, Powdery mildew, Angular black leaf spot, Thrips, Maruca pod borer. Tolerant varieties are ML267,MH 309 and LGG 460.

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:

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 No. 24

BENGALGRAM/CHICK PEA

Cicer arietinum

F-Leguminaceae

It is also known as Gram (or Chana).

Origin: Western Asia (Turkey)

Economic importance:

Chick pea contains 21% protein, 2.2% fat, 62% carbohydrates.

⇒ It also contain calcium of about 190 mg/100g; Iron 90.5 mg/100g; Phosphorus 280 mg/100g.

⇒ Among the pulses, chick pea has **relatively lower protein content** but of higher biological value and protein digestibility.

⇒ Germinated seeds can cure is scurvy"

⇒ An acid liquid from the granular hairs of leaves and pods contains twoacids.

They are i) Malic Acid (90-96%)

ii) Oxalic Acid (4-10%)

Which are used in the preparation of drugs, and are prescribed for the intestinal dis-orders and blood purification.

⇒ Soaked seed and husk are fed to cattle.

Area, Production, productivity:

On the basis of the cultivated area, chick pea is the 19th most crop grown in the world.

⇒ 77% of total area and production in world is from India.

⇒ Important countries growing chick pea are Pakistan, India, Turkey, Mexico, Burma, Ethiopia.

	WORLD	**INDIA**	**ANDHRA PRADESH**
Area (M.ha)	10	7.5	0.12
Production (M.t)	7.5	6.1	0.09
Productivity (kg/ha)	750	810	750

In India – Madhya Pradesh ranks first in Area (2.6 m.ha), production (2.4 m.t) with a productivity of 930 kg/ha followed by Rajasthan.

- Then followed by Rajasthan.
- The three states Madhya Pradesh, Rajasthan, Uttar Pradesh accounts for 84% of Area, 86% production in the country.
- National average productivity is 810 kg/ha where as higher average productivity is 1.8 t/ha in Egypt.

SOILS: It can grow on wide range of soils from medium to heavy black soils. It does well on Black cotton soils and sandy loams.

- Optimum pH required for crop growth is 6.0 to 7.5 (>8.5pH not suitable)
- It does not withstand water-logging, saline and alkaline conditions.

CLIMATE: It is a rabi pulse crop and requires cool humid weather and mainly suitable to North India.

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

Types and Varieties in Chickpea:

There are 2 important varietal types available in India They are:

1) Kabuli type

2) Desi type.

Mostly cultivated type of chick pea is Desi type.

Differences between Desi type and Kabuli type:

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

Other varieties: Radhay, Gwalior, Vikas, Chabba

Wilt tolerant variety: Vishal, Vijay, Avarodhi

Popular varieties grown in A.P: Annegiri, Kiranthi, Jyothi, Swetha.

SEEDS & SOWING:

Seed rate: Desi Type → 65-70 kg/ha

Kabuli type → 80-90 kg/ha

Spacing: Desi type → 30x10cm.

Kabuli type → 45x10cm.

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

Depth of sowing: 6-8 cm.

- If delayed, sowing of chick pea results in possibility of effecting wilt diseases.
- Early sowing results in excessive, vegetative growth and poor setting of pods.

FERTILIZERS

The crop comes up well with a residual fertility. But the recommended fertilizers are:

	Rainfed chickpea	Irrigated
N (kg/ha)	10	20
P (Kg/ha)	40	60
K (Kg/ha)	20	40

'zn' deficiency can be corrected by 0.5% $ZnSO_4$. spray or soil application of 25kg /ha Zinc Sulphate which is effective in increasing the yields.

Bio-fertilisers: Seed treatment with the Rhizobium strain namely

Cicer rhizobium will increase the Nitrogen fixing ability of the plant and thereby yield will be enhanced by 20-30%.

IRRIGATION:

55% area of chickpea is under Rainfed.

Where under drought conditions, the crop requires 2 irrigations at critical stages .

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

⇒ If water is adequate then four irrigations are recommended at:

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

⇒ Evaporative demand is high in South India, Irrigation at that time can double the yield.

⇒ Evaporative demand is low in North India, Irrigation can cause excessive growth leading to lodging.

WEED CONTROL:

Weeds become problematic in chickpea due to its short growing nature.

Pre emergency herbicides are Bentazon (1.0-1.5 kg/ha)

Pendimethalin (0.5-1.0 a.i kg/ha)

Pendimethalin (0.5%) + Imazethpyr (50g)

Preplant incorporation of Fluchloralin (0.5 – 1.0 a.i kg/ha)

Trifluralin (0.5-0.7%)

HARVESTING:

In North India chickpea duration is 160-170 days. In South India crop comes to harvesting with in 90-110 days.

⇒ Crop is harvested when leaf turns to reddish brown and starts leaf shedding.

⇒ Harvesting is done during morning to avoid shattering of pods.

⇒ Plants are pulled out or cut with a sickle and carried to threshing floor.

THRESHING:

The harvested plants are dried in sun for about a week and then it is threshed under the feet of cattle (or) by beating with sticks.

⇒ Then the grain is collected and it can be used directly (or) crushed.

CROPPING SYSTEMS:

Rice – Chick pea

Cotton – chickpea

INTERCROPPING:

Chick pea + Mustard

Chick pea + Linseed

Chick pea + Sunflower

Chick pea + Coriander (for South zone)

YIELD: 20-25 q/ha.

COLLECTION OF ACIDS FROM CHICK PEA CROP:

The leaves and pods of Bengalgram on the growing crop are coated with thin film of Malic acid (90-96%); oxalic acid (4-9%).

⇒ They are encrusted on leaves and pods and dissolved on dew and settles on plants during winter season due to this the plants give sour taste.

⇒ These Acids are considered to have some medicinal properties and they may be collected and stored.

Procedure of Collection: For collection of acids a thin clean piece of cloth like Muslin cloth is spread over the crop during night.

⇒ Acids are soaked in the cloth that are dissolved in dew during night.

⇒ Now the cloth has been absorbed these acids and the cloth is squeezed and thus acids are obtained.

⇒ This process is to be repeated until all acids are collected.

⇒ After the collection is over, allow the concentrate solution in sun to evaporate and thus crystallization takes place.

⇒ This crystallized acid is similar to the taste of vinegar.

⇒ Which is used for curing of indigestion and stomach complaints.

About 4 – 4½ kg of acids may be obtained from 1 ha of crop.

Lecture No. 25

COWPEA

(Vigna ungiculata)

Origin: Central Africa (or) India

OTHER NAMES: Black eyed pea, southern pea, china pea, Marble pea.

⇒ It is also called as weed smothering crop.

Economic Importance:

⇒ It can be used as pulse, fodder, green manure crop

⇒ Feeding value and forage value of cowpea is very high compared to other legumes.

⇒ Crop gives heavy vegetative growth and covers ground very quickly thus it checks weed growth.

⇒ It is a erosion resistant crop

⇒ It is an important alternate pulse crop on dryland areas.

⇒ Cowpea seeds are highly nutritious with high protein (23-24%), carbohydrates, minerals and vitamins.

Area and production :

Cowpea grown throughout the tropics and subtropics as a grain legume mainly for drybeans, green vegetables, forages and cover crop

⇒ Major area lies in Africa and few countries of Asia, America, Australia and Europe

⇒ Highest cowpea production nations are Nigeria, India, Brazil

⇒ Annual global production 2million tonnes from an area of 5million.ha.

India: In India Cowpea is grown in about 0.5 million ha with an average productivity of 600-750kg grains /ha. Major states grown cowpea are Maharastra, Karnataka, Tamilnaidu, Madhyapradesh, Rajasthan, Andhra Pradesh.

Soils: Cowpea grown in wide range of soils from sands to clays. The primary soil requirement with good drainage and presence of nitrogen fixing bacteria

- It can thrive well in acid soils (pH-6)
- the crop is moderately susceptible to soil salinity

Climate:

- It is a warm weather crop adopted to tropics and subtropics
- It can tolerate heat and dry weather and grown at low rainfall of 300-400mm (drought resistant)
- Maximum yields obtained at day/night temperatures around $27^o/22^oc$
- It is a short day plant sensitive to cold and killed by frost.

Varieties: Pusa 152, Pusa Sawani, Amba, PTB1 (Kanakamani) PTB 2 (Krishnamani), latest varieties – Anarwara, varun, Pusa Phalguni, 288, Paiyur 1, Pusa Dophasali, Pusa Bargathi, Russian gaint,
pusa barsati (Cowpea fodder)– Pusa Baisaki,

Seed rate & spacing:

Pulse – 22-25 kg/ha

Fodder – 35 – 45 Kg/ha

Green manure – 35-40 kg/ha

Spacing – 30-45cm in between rows and 8-10cm between plants.

FERTILIZERS AND BIO-FERTILIZERS:

Application of 15-20 kg N/ha is found optimum.

⇒ Application of higher doses of nitrogen may reduce nodule number and nodule growth and adversely affect the nitrogen fixation capacity.

⇒ Application of 30-50kg P_2O_5, 25kg K_2O/ha gives better yields.

Bio-fertilizers: Rhizobium inoculation also influences growth and yield of cowpea.

- Treat the cowpea seed with appropriate Rhizobium strain at initial stages, increases soil nitrogen availability, organic matter content, moisture status of soil determine the response to nitrogen applied through fertilizers.

Water management:

1-2 irrigations may be required at critical moisture stress period.

- moderate moisture stress is essential for timely inducement of reproductive phase.
- Critical stages for irrigation are-flowering and pod filling
- Irrigation at 75% available soil moisture in top 30cm soil has been found beneficial to achieve higher yields.
-

Weed management:

Unrestricted weed competition reduces cowpea yield to extent of 70-90%

⇒ Presence of weeds throughout season causes 75% yield loss.

⇒ Growth of weeds during first 40-45 days reduces yields by 59%.

Control: Clean cultivation, weed free seeds usage, optimum plant population reduces weed problem.

⇒ One hand weeding after 30 days reduces adverse effect of weeds.

⇒ Application of pendimethalin @0.75kg/ha as pre emergence or fluchloralin @ 1kg/ha as pre plant incorporation.

CROPPING SYSTEMS:

Inter-cropping:- Sorghum + cowpea
Maize + cowpea
Pearlmillet + cowpea
Pigeonpea + cowpea

Cropping sequences: Rice-wheat – cowpea
Pigeonpea-wheat – cowpea
Sorghum + pigeonpea – cowpea
Cowpea-wheat – Greengram
Cowpea-cotton – wheat

Harvesting and post harvest care:

Varieties exhibiting synchronous maturity, harvesting is done by uprooting or cutting entire plant at ground level when plant shows 90% maturity.

-harvested produce is sundried on threshing yard and threshed by trampling either by animals or tractor and winnowed.

-If the varieties does not have synchronous maturity pods have to be harvested manually.

Yield: Fodder yield – 14t/ha.

Grain yield - 3-4q/ha.

<u>HORSEGRAM</u>

Dolichos biflorus (or)

Macrotyloma uniflorum

Origin: India

Other names: Rabi pulse crop, poorman's pulse crop, test crop for drought, crop of virgin soils.

- Ulavalu, Kavam, heruli, Kulthi
-

<u>AREA, PRODUCTION, PRODUCTIVITY:</u>

Horsegram is cultivated over an area of 1.7 million hectares with an estimated production of 0.58 million tonnes of grain.

- The largest area under this crop (0.56m.ha) is in Karnataka.
- It is extensively grown in Karnataka, Andhra Pradesh, Tamilnadu, Madhya Pradesh parts of Maharastra.
-

<u>Importance</u>: The grain is used as human food and also concentrated feed for cattle.

<u>Soils</u>: It can be grown in wide range of soils, mostly on poor lateritic soils and also grown in red and black soils.

Climate: It can be invariably grown as rainfed crop in areas of low rainfall.
Seed rate and spacing: It is grown mainly in August-November
Seed rate is 25 kg/ha for grain.

Seed rate is 40 kg/ha for fodder.

Spacing required-30x10cm (short duration)
Long duration – 45x10cm.

Varieties:

State	Varieties
Andhra Pradesh	PDM1, PDM2, VZM1, PHG-62m PHG-9, VZM2, PDP1, Palem1
Bihar	BR 5, Birsa Kulthi1, Madhu
Himachal Pradesh	HPK 2, HPK 4 (Baizu Kulthi)
Karnataka	BGM, Behhal, Hurali1, Hebbal Huarali2
Orissa	S27, S28, S39, S164
Tamilnadu	CO1, 35-5-122, 35-5-123

Other varieties: BGM1, VLG4, TPK2, TPK6

Fertilisers: The crop normally receives no fertilizers. A basal dose of 10kg N, 25kg P_2O_5, 20kg K2O ha^{-1} are recommended.

Irrigation: This crop does not require much irrigation as it is grown as rainfed crop irrigation is essential at flowering and pod formation stage.

Weed control: Weeding should be done 25-30 days after sowing. Application of pendimethalin @0.75kg/ha as pre emergence herbicide.

Cropping systems:

Crop rotation –	Groundnut – Horsegram
	Sesame – Horsegram
	Mesta – Horsegram
	Upland paddy – Horsegram
Inter cropping:	Ragi + Horsegram
	Maize + Horsegram
	Niger + Horsegram

Harvesting and storage:

Harvesting is done by pickings in the indeterminate types and cut the entire plant in determinate type. Threshing done with the help of sticks to separate seed. Then the seeds are stored in gunny bags. Protect the seed from stored grain pests it must treat with edible oil.

Quality considerations and By product utilization:

⇒ Horsegram is commonly termed poorman's legume. The average protein content is 22%, fat 1%, carbohydrate 62%, ash-4.5%

⇒ Cooked seed and soups are nutritious

⇒ Roasted grains are salted and consumed as confectionary items.

⇒ Horsegram finds greater use as animal feed particularly for horses and cattle.

⇒ Green foliage is an excellent fodder source in South India.

References: Agronomy of field crops – S.R.Reddy Advances in pulse production technology – L.Jeswani, B.Baldev, Text Book of field crops production – Dr.Rajendra Prasad.

Lecture No.26

Fodder/Forage crops-Importance, classification of fodders– Hay and Silage their preaparation 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 .

FODDER SUPPLY, DEMAND AND DEFICIT(MILLION TONNES)SCENARIO IN INDIA

YEAR	SUPPLY			DEMAND			DEFICIT			
	GREEN	DRY	TOTAL	GREEN	DRY	TOTAL	GREEN	%	DRY	%
1995	379	421	800	947	526	1473	568	60.0	105	20.0
2000	385		813	988	549	1537	603	61.0	121	22.0
2005	390	443	833	1025	569	1594	635	62.0	126	22.1
2010	395	451	846	1061	589	1650	666	62.8	138	23.4
2015	401	466	867	1097	609	1706	693	63.4	143	23.4
2020	406	473	879	1134	630	1764	728	64.2	157	24.9
2025	411	488	899	1170	650	1820	759	64.9	162	24.9

SOURCE:Patil et.al (2005) forage production and feeding during scarcity. International book distribution co.lucknow the gap between supply and demand is widening year to year due to many reasons and low productivity of the forages is main reason.

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 digestable 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 = Cell wall constituents –Hemi cellulose.

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

DCP = Feed protein – Feces protein (N x 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.

TDN = CP + NFE + CF + 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.

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 CYCLE

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 2.Jowar or sorghum	*Zea mays* *Sorghum bicolor*
3.Pearl millet	*Penisetum americanum*
4.Finger millet or Ragi	*Eleusine coracana*
5.Teosinte	*Euchlaena mexicana*
6.Foxtail millet or korra or Italian millet	*Setaria italica*
7.Prosomillet or variga	*Panicum milliaceum*
8.Little millet or sama	*Panicum miliare*

Winter or Rabi cereals (B)

9.Oats	*Avena sativa*
10.Barly	*Hordeum vulgare*

Perennial Non-legumes (C)

1.Hybrid Bajra Napier	*P.americanum x P.purpureum*
2.Guinea grass	*Panicum maximum*
3.Para grass	*Brachiaria mutica*
4.Anjan grass or Buffel grass	*Cenchrus ciliaris*
5.Anjan grass or Buffel grass	*Cenchrus setigerus*
6.Rhodes grass	*Chloris gayana*
7.Dinanath grass	*Pennisetum pedicellatum*
8.Napier grass	*Pennisetum purpureum*
9.Rye grass	*Lolium perenne*

Annual or Seasonal legumes (D)

1.Cowpea	*Vigna anguiculata*
2.Field bean or Lab lab	*Dolichos lablab*
3.Cluster bean(Guar)	*Cyamopsis tetragonaloba*
4.Sunhemp	*Crotalaria juncea*
5.Pillipesara 6.Berseem	*Phaseolus trilobus* *Trifolium alexandrium*
7.Horse gram	*Macrotyloma uniflorum*

Perennial Legumes (E)

1.Lucerne	*Medicago sativa*
2.Stylo 3.Siratro	*Stylosanthes hammata* *Stylosanthes scabra* *Macroptilium atropurpureum*
4.Hedge Lucerne	*Desmanthes virgatus*
5.Perennial groundnut	*Arachis glabrata*

Tree species (F)

1.Subabul	*Lucaena leucocephala*
2.Khejri	*Prosopis cineraria*

IX. Other fodders

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

X. Miscellaneous fodders:

1. Miscellaneous legumes: Chick pea,pigeon pea
2. Root crops: potato, sweet potato
3. Crop residues: Agricultural byproducts.
4. Aquatic fodders: Water hyacinth, BGA.
5. Miscellaneous fodder trees: Subabul, Sesbania.
6. Introduced fodder plants : Timothy grass, Guinea grass
7. Indigenous fodder plants: Marvel grass.
8. Seeds or grains used as fodder: Bengal gram.

XI. Crop residues

1. Roughages

a. Succulent dry crops.

b. Green fodder

c. Agricultural by products.

2. Concentrates

Ex: Oil cakes example: Groundnut cake and Seasame cake .

Preparation and preservation of silage and hay

The supply of nutrients from grasslands and harvested forages is seasonal in most of the regions of the world because of either low temperatures or drought. Thus the preservation of harvested forages becomes an essential part of ruminant livestock feeding systems because of following reasons.

1. In *Kharif* season, fodder supply is exceeding the demand due to favourable crop season. The excess fodder can be preserved in green (silage) or dry (hay) form and utilized in lean months (March-June).
2. Unexpected drought or cold or cyclones cannot affect the productivity of animals if fodder is preserved in advance. It acts as insurance to the farmer.
3. Anti nutritional characters of the crop can be reduced due to changes in physical / chemical / biological composition.
4. The palatability of the fodder can be improved by using preservatives and additives during preservation.

The preservation of forages is broadly divided into two methods.

1. Silage making
2. Hay making

The objective of silage making is to preserve the harvested forage in green form by anaerobic fermentation.

The objective of haymaking is to achieve a rapid moisture loss after cutting so the forage can be preserved in dry form with minimum losses from weathering and microbial degradation.

1. Silage making:

Silage : It is the process of preservation of green fodder under anaerobic conditions at moisture content of 65-75 % in specialized structure called silo. The process is called ensiling and the end product is called silage.

Wastelage: It is the process of preservation of organic waste (vegetable waste, slaughter house water, organic waste of any industry) under anaerobic conditions at moisture content of 65-75 %.

Haylage: It is the process of preservation of green fodder with moisture content of 30-50 % under anaerobic conditions.

	Wastelage	Haylage
1.	The process of preservation of organic waste along with green fodder under anaerobic conditions	Silage making from material with high dry matter content under anaerobic conditions
2.	Nutritional losses are less and only method to efficiently utilize. The organic wastes Ex: Vegetable waste, slaughter house waste	Nutritional losses are more hence not recommended. Ex : Maize, sorghum
3.	Moisture content may be varying depending on the organic material to be ensiled	Moisture content is 30-50 %.
4.	Organic waste may be agro based or industrial	Waste is mainly agro based with high dry matter content

Advantages of ensiling

1. Surplus green fodder abundantly available in rainy season can be preserved as silage for feeding during lean season.
2. Silage can be prepared in rainy season of humid climate where weather do not permit for hay making.
3. Silage can be prepared from plants with a thick stem.
4. It is highly palatable and slightly laxative.
5. Ensiling increases voluntary intake of coarse forage.
6. Ensiling destroys the germination capacity of majority of weed seeds.
7. The organic acids produced during ensiling are easily digestible by ruminants.

8. There is lesser less of carotene in silage making than that of hay making.

9. Fire hazard is not there.

10. Green fodder can be stored for a very long period

11. Silage requires less space and accommodate 230-270 kg/cubic meter, Where as hay can accommodate 66-67 kg/cubic meter.

Disadvantages:

- Transportation problem is generally experienced in silage than that of hay.
- Permanent structures for preparing silage are required.
- Wastage may be high due to affluent losses or otherwise, if it is not properly Made.
- Animals do not accept poorly prepared silages.
- Materials

Materials required: Green fodder, Chaff cutter, Silo pit, Rock salt, low-grade jaggery (or) Molasses, urea. Tractor for compaction of the pit, Polythene sheet.

Types of silos:

I) Depending upon the type of material

i) Kaccha silos

ii) Pucca silos

i) Kaccha silos : Temporary silos and locally available material is used. Eg : coconut leaves.

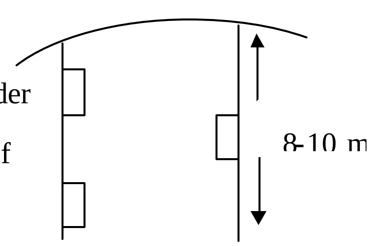
ii) Pucca silos: Constructed silos. Permanent depending upon the type of material they are called as:

a) Cement silos

b) Stone silos

c) Brick silos

II) Based on shape / placement of silos:

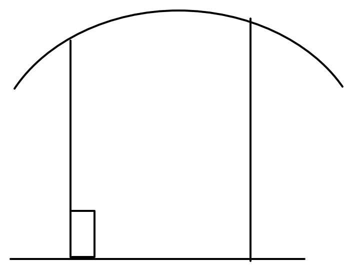


a) Power silos / upright silos: Tower like structure, cylinder in shape above the ground with dome shaped lid. Waterproof airtight doors at different heights. Fill the soils by machines.

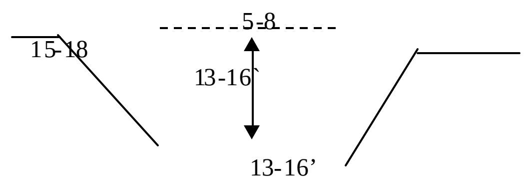
It is popular in advanced countries.

Draw back: There is possibility of damage to silage making process because of presence of more doors as the air / water entry is possible..

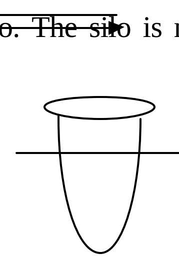
2) Oxygen limiting silos: Silos having one door at bottom so that they can reduce the entry of water and air.



3) Trench silo: The height of trench is 5-8 feet. The bottom is 13-16feet. Ramp is 15-18 feet. Trench silos are observed in all dairy units. The sides and bottom of trench are lined with bricks, stone or cement. The ramp is provided on both sides for easy moving of tractors for compaction.



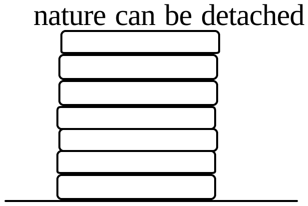
4) Clamp silos: are fixed in the soil up to the $3/4^{th}$ of silo. The silo is made up of copper or Aluminum or earthen pots. It is covered with a dome shaped lid and kept airtight by plastering with cow dung. It is used for high valued forage like Lucerne.



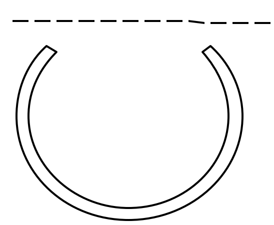
5) Bunker silos: The bunker silos are constructed below the soil or above the soil.

1 feet Cement rings are coiled one over the other to form a bunker. The cement rings are attached with cement. Depending upon the height of silo the cement rings are used.

Bunker silos are useful for small-scale silage making. They are semi permanent in nature can be detached if not needed.



Bunker silo



Pit Silo

6) Pit Silo: It is a temporary structure made below the soils and lined with locally available stones and soils. It is mostly practiced at farmers level, but losses are more in this type of silo.

Crops suitable for silage: All cereal crops like maize, jowar, bajra are suitable for silage making as they are rich in carbohydrates.

- Grasses or mixtures of grasses and clovers are good for silage making.
- Thick stemmed plants are suitable for silage making as chopping is done.
- Paragrass is not suitable because of high moisture content.
- Legumes are not suitable for silage making as they are rich in proteins, but we can add 1/3 of the legumes to 2/3 of cereals to form balanced silage.
- First silage was done in year 1917 at Kansas Agricultural University, USA on Lucerne crop.
- Best silage can be made from maize crop.
- Cereal crops like sorghum or ragi should be harvested for silage between flowering and milk stages.If harvesting is delayed, Carotene losses occur.
- Miscellaneous crops and by products of crops like sugarcane tops, beet root tops, sweet potato vines, peas and beans, surplus fruits and vegetables.

Selection of the site for silo pit:

- The site should be easily approachable from the forage field as well as dairy farm.
- Chaffing unit should be adjacent to the silo.
- Area should be high or elevated and ground water should be > 3 m depth.
- It should be 100 meters away from the cropped field as well as from FYM pits.

Method of filling of silo:

1) **Harvesting of the crop**: All the cereal crops should be harvested at dough stage. The perennial crops like NB hybrid and guinea grass should be harvested at 65-70 % moisture content.

2) Chaffing: All the harvested fodder should be cut into pieces of 2-3 cm in length by using chaff cutter. Chaff cutter may be manually operated or machine operated. Chaffing is an important practice in silage making. Without chaffing, the fodder compaction in the silo is not perfect.

3) Lining of the sides and bottom walls of the silo pit:

The bottom and sidelines of the pit should be lined with paddy straw to avoid contact of green material with the walls of the pit.

4) Chaffed green material is transferred to silo pit:

1 cubic feet of silo preserves 15 kg of green material. A silo pit having storing capacity of < 250 kg is not economical.1 m^3 of silo pit can preserve upto 230-270 kg of green material.

5) Fill the silo pit layer by layer with a thickness of 15-20 cm/day:

Compaction should be followed each day after filling the pit. The compaction can be done using manually operated stone rollers, bullock drawn stone rollers or by tractors. Additives or preservatives are added at each layer.

	Additives	Preservatives
1.	These are materials which improve anaerobic fermentation by increasing carbohydrate content	These are materials, which improve keeping quality or longevity of the material.
2.	They improve the nutritive quality of silage as they are rich in Carbohydrates Eg. Molases @ 8-10 kg/ton of green fodder	They add taste and aroma to the silage but nutritive value is not increased. Eg : Salt @ 1-2 kg/t of green fodder.
3.	Cribbled grain flour @ 40-50 kg/ton of green fodder	Na metabisulphite @ 3-5 kg/t of green fodder or urea @ 3-5 kg/t of green fodder. Citrus pulp (or) orange pulp (@) 40-50 kg/t of green fodder.

Fill the silo pit layer by layer till it reaches the dome shape and 1 meter above the surface. Cover the silo pit with a polythene sheet and keep it for 3 days. We can observe reduction in height after 2-3 days by 40-50 cm due to compaction of the layers and to release of air present in between the layers.

6) Permanent closing of the pit

Cover the silo pit with a thick polythene sheet and above that cover it with 5-10 cm layer of soil (or) sand followed by plastering with cowdung paste.

The silo pit is kept as it is for 1-3 months with regular inspection for cracks. Cracks should be again closed with cow dung paste.

The silage is ready after 3 months and is used for animal feeding. For an adult cow silage material can be given @ 3 kg / 100 kg body weight.

7) Opening of the pit: The silo pit should be opened at any one corner. After taking silage material daily, it should be again closed with polythene sheet and kept airtight. Never open the pit completely as it damages the silage material and silage becomes not suitable for animal consumption. If silage material is not required, the silo pit can be stored even up to 18-24 months with regular inspection for cracks.

Changes that occur in the silo

These changes are divided into 3 types

1) Physical changes
2) Chemical changes
3) Bacterial changes
4)

All these three changes are divided into 4 phases.

I Phase

II Phase

III Phase

IV Phase

Phase I: Immediately after closing silo pit, some of the aerobic bacteria breaks down into CO_2 & H_2O.

$$C_6H_{12}O_6 \xrightarrow[\text{Aerobic bacteria}]{} 6\,CO_2 + H_2O$$

2) Because of respiration, there is increase in CO_2 content. This increase in CO_2 increase the temperature which causes break down of carotene into pheophytin.

3) With the increase in temperature and the absence of air, the aerobic bacteria disintegrates and at the end of phase I, the anaerobic bacteria will start working.

4) The longevity of phase I dependent on compaction of the silo pit. If it is > 7 days, the silage material is damaged and used by aerobic bacteria.

Phase II: In this phase, all the anaerobic bacteria like lactobacillus, clostridium, streptomyces, E. coli are present. So at the end of phase II, Lactobacillus will become dominant and start producing lactic acid. The favourable conditions for lactic acid. fermentation are :

Temperature : 27-37^{o}C

Moisture : 65-70 % + Lactobacillus

$$C_6H_{12}O_6 \xrightarrow[\text{Bacillus}]{\text{Lacto}} \underset{\text{Lactic acid}}{2\,(C_3H_6O_3)}$$

The homofermentative lactic acid bacteria increase the amount of lactic acid where as heterofermentative lactic acid bacteria increases the amount of minitol which gives unpleasant small. At the end of phase II, the pH reaches 3.4 to 4.2 due to production of lactic acid.

Phase III:

Only lacto bacillus species is active in this phase. Lactobacillus is active till the lactic acid concentration is 1 % of the silage material on weight or volume basis. At the end of phase III, lactic acid concentration become static and pH also stabilizes at 4.0.

Phase IV: It is a stable phase and can remain upto 18-24 months. But with entry of air and water the lactic acid is further degraded into butyric acid which causes foul smell and damages the silage.

$$2\,(C_3H_6O_3) \xrightarrow[\text{Clostridia}]{\text{Air+ water}} C_4H_8O_2 + 2\,CO_2 + 2H_2O$$

Favourable conditions for butyric acid fermentation

a) Entry of air and water into the pit

b) Inadequate degree of acidity (> 4) resulting in increased number of clostridium bacteria.

Physical changes

Colour change from green to olive green because of increase in CO_2 due to respiration. Temperature of silo pit increase.

The moisture content in pit is also increased because of oozing and the material becomes laxative.

Chemical changes

Respiration takes place by aerobic bacteria Carbohydrates break down by lactobacillus into lactic acid.

Lactic acid fermentation

$$C_6H_{12}O_6 \xrightarrow[\text{Temp. } 27^oC - 37^oC]{\text{Lacto bacillus}} 2\,(C_3H_6O_3) \text{ lactic acid}$$

Homofermentative bacteria - produce only lactic acid

Heterofermentative bacteria – produce acetic acid, butyric acid formic acid. Hence, more homofermentative bacteria is congenial than heterotermentative bacteria.

Proteins are converted to amino acids and carbohydrates, fats are converted into simple fatty acids. Because of this, silage is easily digestible by the animal and give instant energy.

3) Butyric acid fermentation

It is a unfavourable fermentation. It occurs due to

- Entry of water and air.
- pH will not reach 4. moisture > 70 %

$$\text{Lactic acid} \xrightarrow{\text{pH} > 4} \text{butyric acid}$$

$$2\,(C_3H_6O_3) \longrightarrow C_4H_8O_2 + CO_2 + H_2O$$

Cause foul smell

5) Bacteriological changes

Phase II

Aerobic → Anaerobic → Dominant III Phase

Lactobacillus lacto bacillus

Clostridium

Unfav. ↓ pH > 4

Conditions

(Butyric acid) Clostridium become dominant IV Phase

Losses During Silage Making:

1) **Leaching loss**: Nutritional loss due to oozing of cell sap from cells which reaches bottom layers of silo pit. It Leads to corrosiveness and damage the root system of nearby crops. It also has high polluting strength and they may create poisonous gasses when come to contact with FYM pits.

2) **Heated silage**: If the moisture content of forage is < 60 – 65 %., the dry pieces of forage do not compact properly and entrap air in between the pieces of forage. This causes aerobic respiration for more than 10 days resulting in increasing temperature upto $45^{o}C$. This causes combusting or burning of the forage in the patches. This is called as heated silage. The burn patches become unfit for animal consumption and gives foul rotten smell.

3) **Silo gases:** Silo grasses like CO_2, NO_2 are poisonous and increase the environmental pollution and also in the soil.

4) **Field losses:** The losses, which occur after harvesting of crop till it is filled in silo pit are field losses. If the crop is not ensiled or transferred to the silo pit on the same day the losses may be 8-10 % due to loss in moisture considerable loss of dry matter may occur due to shattering of leaves and during chaffing period.

Qualities of good silage

1) Colour : The colour should be olive green to golden ye llow colour with pleasant aroma of lactic acid.
2) pH – pH should be 4 (acidic taste and odour).
3) It should be free from by butyric acid, moulds and burnt patches.
4) Ammonical Nitrogen is less than 10 % of the total Nitrogen.

HAY MAKING

Hay making is the Process of preservation of dry fodder under aerobic condition at a moisture content of 9-10 %.

Materials required: Green dry fodder, Threshing floor, bamboo sticks, ropes.

Suitability of the crops for Hay making

1. Cyanodon dactylon or Doob grass (or) Bermuda grass: is preserved as best hay.
2. Thin stemmed succulent leaved plants are suitable for hay making process.

   eg: Oats, barley, multicut bajra, sorghum, maize etc.
3. Cereals are more suitable for the conservation of fodder as hay. Legumes loose moisture quickly and the leaves fall off easily.
4. Coarse leaved thick-stemmed grasses are not suitable for hay making.

   eg : NB hybrid and guinea grass.

5. Paragrass is not preserved as hay. Though succulent at high moisture content (80-90 %) it develops coarseness if it reduces the moisture content to 15 % and becomes unpalatable.
6. Legumes like cowpea, berseem, Lucerne can be preserved as hay but care should be taken to prevent shattering of leaves as leaves contain 75% of proteins and total digestible nutrients and 90% carotene, hence shattering of leaves leads to 75% of loss of nutrients.
7. Legumes like sunnhemp and pillipesara can be preserved as hay in between the layers of paddy straw.
8. Spear grass can be preserved as hay before flowering only. After flowering, it develops awns in the spikelets.
9. In Anjan grass (*Cenchurus ciliaris*), harvesting of 2nd cut and after cuts are suitable for hay making.
10. Hay can also be prepared from leguminous crops but it needs a lot of skill and experience so that the loss of leaves which are more nutritious is minimized.
11. The best way to prepare hay is to mix a portion of legume species with the cereal. This will help in better aeration and uniform drying of the cereal fodder.
12. This mixture also provide a rational diet of legume and carbohydrate component in 1:3 proportion for feeding the animals.
13. Lucerne is the best legume to prepare hay among different leguminous crops because it will loose the moisture relatively at a quicker rate than the others. Berseem looses its moisture slowly than the others.

Steps in preparation of Hay:

- Harvest the crop at 50 % flowering. This is the ideal stage to conserve the fodder as hay because it contains maximum quantity of nutrients in the vegetative part.

- Harvesting should never be delayed until seed filling stage. If the harvesting is delayed, the nutrients are translocated into the seed and the fodder becomes fibrous, which is not palatable to the animals.
- Cut the fodder crop at about 1-2 inches above the ground level. In advanced countries, movers are used to mow or cut the crop.
- The harvested crop is laid down on one side of the row. This is known as `Windrow'. The harvested fodder is allowed to wilt for about 2-3 days. During this period the leaves loose moisture more quickly than the stem. When the crop reach about 40 % moisture, then bundle the fodder.
- Keep these bundles in an upright direction. These bundles are known as 'cocks'. The leaves reabsorb the moisture from the atmosphere and become pliable. This will minimize the risk of falling down of the leaves.
- After 2-3 days, loosen the bundles and heap the fodder on the floor. These heaps are known as 'Swath'. Each swath is teddered with a tedder. This will fluff the fodder material and help better circulation of air.
- After another 2-3 days, swath is inverted with the help of swath inverters. This will help in uniform drying of the fodders in different layers. Once the moisture content has come down to about 25 %, the fodder is baled with tractor drawn equipment.
- After the moisture content of fodder reaches to 15 %., the heaps are bundled into small bundles of convenient sizes for staking. These bundles are called "cocks" and the cocks are transported to stalked area for stalking.

Then the fodder is stacked as hay for future use. Stacking: is of two types.

i) Indoor

ii) Out door

Stacking area should be a high-elevated area. Ground water table should be > 5 m deep and is perfectly leveled. Indoor staking provides protection against rain and sunshine, hence leaching and bleaching losses are less. A trench of 1feet deep and 45 Cm width is provided on both sides of the stack to collect rainwater and also to protect against rodents. The dimensions of stack depends on availability of the fodder material optimum is 15-18 feet height, 5-8 feet width.

Types of Hay Curing:

1. Floor curing

- The harvested fodder is spread uniformly in a thin layer on floor. This is allowed to dry under sun.
- The fodder should be turned upside down frequently to give an equal chance of drying to the lower layer.
- The fodder should be shifted to a safe place under the roof so that there is no chance of direct contact of this fodder with the possible dewfall or drizzling.
- Again shift the material to the drying floor in the morning. Continue the process until the moisture content is reduced to 15 %. Then stock the material where it is desired to store for future use.

2. Tripod method

A tripod is made with the help of 3 bamboos, wooden poles or iron poles which are tied horizontally with wooden or bamboo poles or iron rods. The fodder is tied to these horizontal stalks with the help of strings.

3. Fence curing

The harvested fodder is tied with string to the iron fence on the boundaries of the farm or they are spread over the live fence of the boundary. They are moved to a protected place in the evening and tied again to the fence on the next day.

4. Bench curing: The fodder is spread in thin and uniform layers on the benches made of wood or bamboo.

5. Barn curing

- Barns are the artificial heaters. They are made up of brick, cement, iron and steel. They are highly expensive. The fodder is accommodated in the barn.

- Heated air is blown in through the bottom portion of the barn, which gets circulated inside, dries the fodder and is blown out through an outlet provided at the top.
- A temperature of 100°C is maintained while blowing the air inside with the help of blow ers.
- Moisture content is reduce to very quickly.
- It should be taken out of the bran when the fodder reaches the desired moisture content. This process is repeated.

Losses During Hay making:

	Type of loss	Material lost	Reasons
1.	Shattering of leaves	TDN, minerals and vitamins	Leaves contain 75 % of TDN and minerals. Hence shattering of leaves causes major loss of nutrients
2.	Bleaching	Carotene, vitamin A	Exposure to sunshine cause bleaching losses
3.	Leaching	TDN, minerals, vitamins and NFE (Nitrogen free extract).	Such losses are more when rainwater enter into stacked area.
4.	Fermentation	Starch, simple sugars, proteins which are oxidized to CO_2 and H_2O	When hay is stored at high moisture content, these losses occur.
5.	Oxidation loss	Sugars and starch	When rainwater makes the hay to wet condition. The oxidation of nutrients takes place.

Advantages

1. Method of doing haymaking is less expensive and easy which can be done easily at farmers level.
2. The good quality legume hay may replace certain amount of concentrates in the ration thus reducing the cost of milk production.
3. The fodder can be harvested at the stage where there is maximum accumulation of nutrients in the plants.
4. It is easy to be practice in tropical countries like India where sunshine hours are plenty
5. One cubic meter space can accommodate 66-67 kg of hay.
6. It gives nutritious fodder during lean periods and the productivity of the animal is maintained throughout the year.
7. The monetary returns to the farmers is uniform and there is continuous availability milk and meat in the market.

Disadvantages

1. Hay making process can be done only in a particular season.
2. Weather interruption is common. Palatability of forage material is reduced.
3. Artificial curing is more costly.
4. There is possibility of fire hazard.
5. Leaching, bleaching and shattering looses may occur.
6. Weeds can mix-up during hay making process, which leads to less palatability and bad odour to the hay.
7. It is difficult to make hay from thick stemmed and spiny nature of grasses etc.

Lecture No.27

Introduction- Origin, distribution,soils,land preparation-varities,seasons–seeds&sowing,fertilizer,irrigation,weed management,harvesting,yield and major cropping systems of fodder sorgum and maize

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 Digestable 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 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 thrive in tropical climate with Optimum temperature range of 25^o-35^o 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 Treatmnet with Azospirrilum (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 verities should be adopted .

Irrigation:

Requires less irrigation as it is drought resistant one . Irrigate immediately after sowing and give light irrigation on the 3rd and thereafter can be irrigated at 10-15 days interval depending upon the weather type of the soil.

Weeding :

Hand Weeding twice at 20 & 40 DAS or spraying Atrataf @ 1-1.5 kg ai/ha as pre emergence herbicide followed by one weeding at 40 DAS. To control broad leaved weeds including striga.

Plant protection:

Spray any one of the following plant protection chemicals on the 10th and 17th day of the sowing to control the shootfly : Endosulfan 35EC or Methyldematon 25EC or Dimethoate 30EC 500ml/ha in 250 lite of water . On the 30th day apply Endosulfan 35EC 750 ml/ha or Carbaryl 50WP 1kg/ha or dust the leaf with 10kg/ha.

Harvesting:

Sorghum is harvested when the ear heads are fully emerged and the grain is in the milky or early dough stage. Care is necessary not to cut the sorghum for feeding the animal before its flowering, as otherwise there is a risk of cattle poisoning by the cyanogenic glucoside contained in the young plants. For single cut varieties harvesting at the 60-65 days after sowing (50% flowering stage). In multicut varieties first cut is taken at the 50 DAS and second cut should be taken 40-45 days after the first cut.

Yield:

The yield will be 30-40 tonnes/ha in irrigated single cut varieties. 100-120t/ha/year-Multi cut varieties. Under rainfed conditions the green fodder yield will be about 15-20 t/ha.

Cropping systems : Pearl millet – Lucerne - sorghum

Toxicities :

Three types of poisoning is noticed in fodder sorghum

1. Prussic acid or HCN or Hydrogen cyanide poisoning
2. Toxicity due to Tannins
3. Nitrate poisoning

1. Prussic acid or HCN or Hydrogen cyanide poisoning:

Lethal dose:2 mg/kg body weight .of animal.

In foliage, 200 ppm on wet weight basis & 500 ppm on dry weight basis.

Symptoms:

Excess salivation,Excitement (Restlessness)

Vomiting & difficult breathing

Convulsions, staggering & collapse.

Mode of action :

- Cyanogenic glucoside called as DURRIN enters into blood stream and binds to enzymes in the cells.
- On enzymatic hydrolysis, dissociates to cyanide complex.
- It prevents hemoglobin from transferring oxygen to individual cells and animal dies of Asphyxiation.

Conditions for aggravation:

- More in young leaves than old le aves. Harvesting should be avoided before 50% flowering.
- New plant growth following frost or drought is high in cyanide concentration.
- Rainfed crop and crop attacked by pests & diseases have more concentration. Than irrigated and normal crop.
- Heavy nitroge n fertilization results in high concentration of HCN.

Control measures:

- Cultivate sweet sudan type of jowar varieties.
- Always harvest at 50% flowering.
- Give normal irrigation & N dose.
- Protect the crop from pests and diseases.
- Conservation of sorghum in the form of silage.
- Intravenous injection of 50 ml of 20% $NaNO_3$ followed by 75 ml Na thiosulphate or 3 gr $NaNO_3$ + 15gr Na thiosulphate in 200 ml water.

2.**Tanning Content:**

Cause bitterness and affects palatability and digestibility in forage sorghum.

3. Nitrate poisoning (ppm):

0-3000 – Virtually safe

3000-6000 - moderately safe. limit to 50% of total ration.

6000-9000 – potentially toxic

>9000ppm – dangerous to cattle & will cause death.

Mode of action:

- It oxidizes the ferrous ion of Hemoglobin to ferric state, producing a brown pigment,Methamoglobin.
- This Methamoglobin is incapable of transferring oxygen to body tissues.

Symptoms:

Gastro enteritis

- Abdominal pain and diarrhea
- Color of the body changes to dark brown color.

Treatment:

- Methylene blue @20mg/kg body weight for cattle.
- Antibiotic supplementation
- Additives like rapeseed oil meal, grain mixture, molasses, sodium chloride.

MAIZE (*Zea mays*)

Common name : Makka/ American –Indian corn:Corn

Uses:

- Maize is one of the most important economic plants of the world, serving as forage for cattle.
- Maize can be feed to the animals during any stage of its growth as it is free from toxic effects.
- It also has lactogenic properties.
- It can be used as silage, soilage or hay.

DCP: 6% **TDN**: 63% **CP**: 8-10%

Origin and Distribution

Its origin is in Mexico and it has been cultivated from the pre historic times by the aboriginal people of America. In India major areas for maize cultivation are mainly in Northern and central parts of India along the upper and middle gangetic plains, in the states of Uttar Pradesh, Bihar , Rajasthan, Punjab and Madhya Pradesh.

Climate & Soils:

Maize thrives best in warm climate.(50^o North to 40^oSouth) where the day temperatures are fairly high and night temperatures are not too low. Ideal temperatures are 24^o c – day & 18^o c—night. It can be grown up to an altitude of 3300 metes above msl. This crop require bright sunshine hours, but cannot tolerate frost or cloudy weather and it is Highly sensitive to water logging even for a short period of 5-6hrs. It can be grown in all types of soils. Sandy loam to clay loam soils is best suited.

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:

African tall, Ganga-5,7 &10,Composites : Vijay. Jawahar, Moti, Gaga safed-2,A-de-cuda & APFM- 8.Baby corn & sweet corn types also used as fodder purpose.

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Season :

In Andhra Pradesh maize is grown within the kharif season as rainfed crop from June to September and also in the rabi season as an irrigate d crop from November to march.

Seeds & sowing :

Seed rate in irrigated conditions is 50-60 kg/ha. In rainfed areas 40-50 kg/ha. Dent type of maize varieties are most suitable for fodder purpose.

Spacing: 30x15 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 Azospiriilum (3 packets (600g should be done).

In the parts of Maharshtra maize is dibbled in rows of 60-90cm apart , a fortnight before cutting the plants , maize again dibbled in rows between the standing rows of maize plants and this inter sowing is repeated five or six times to secure green forage all through the year from the same land.

Manures and Fertilizes:

To ensure higher yields liberal manuring is necessary. Maize is very responsive to both nitrogen and phosphorus and it is good practice to apply 45 to57 kg of nitrogen and 22-45 kg of phosphorus in the form of ammonium sulphate and super phosphate with potassium (20kg/ha) in the form of MOP. Band application of fertilizer mixture prior to the sowing is preferred .fertilizer should be applied in divided doses of 1/3 N,total P&K as basal,1/3 N at 25&50DAS.

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 and soil type.

Weeding :

The first weeding is given when the crop is 20-25cm height and a second weeding when it is about 60cm high. For hoeing bullock drawn harrows are more convenient when the crop is sown in rows. Or spraying Atrataf @ 1-1.5 kg ai/ha as pre emergence herbicide followed by one weeding at 40 DAS.

Plant protection:

Spray any one of the following plant protection chemicals on the 10th and 17th day of the sowing to control the shootfly : Endosulfan 35EC or Methyldematon 25EC or Dimethoate 30EC 500ml/ha in 250 l of spray fluid water.

Harvesting :

As a fodder crop it is important to cut maize at the right stage, when the cobs are just being formed, because the feeding value goes down rapidly therafter. If it is for silage, harvest at dough stage.

Yield : The yield varies from 40-50 tonnes/ha.

Cropping systems :

Maize-oats-sorghum., Pearlmillet-Lucerne-Maize

Maize-berseem-sorghum.

Dinanath grass-oats +mustard, maize+cowpea.

Lecture No.28

Introduction- Origin, distribution,soils,land preparation-varities,seasons– seeds&sowing,fertilizer,irrigation,weed management,harvesting,yield and major cropping systems of fodder Cowpea (*Vigna Unguiculata*)

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

Plant characters and uses:

- Annual /perennial bushy climbing herb.
- Trifoliate 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^o 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 dematon 25EC 500ml or dimethoate 30EC 500ml or phosphomidon 85WSC 250ml/ha in 250 litres.of water. stop spraying 15-20 days before harvest.

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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.

Cwpea-sorghum+cowpea-berseem.

Lecture No.29

Introduction- Origin, distribution,soils,land preparation-varities,seasons–seeds&sowing,fertilizer,irrigation,weed management,harvesting,yield and major cropping systems of Napier hybrid

HYBRID BAJRA 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^{o}c.
- It can tolerate low air temperatures but less than 10^{o}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 ad 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 pla nting 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 x50cm .Irrigate the field through furrows and plant the one rooted slip or stem cutting per hole at a depth of 3-5cm 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 upto 2.5 to 2 m ht. Top ¼ is removed and remaining $3/4^{th}$ 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.

45^0 angle method: Stem cuttings are obtained from basal $3/4^{th}$ portion of the plant. Each stem cutting with 2 nodes measures about 30-40 cm inserted in the soil in a slanting position at 45^0 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 pla ced 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 consists 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.

Lecture No.30

Introduction- Origin, distribution,soils,land preparation-varities,seasons – seeds&sowing,fertilizer,irrigation,weed management,harvesting,yield and major cropping systems of Paragrass&guinea grass

Paragrass (*Brachiaria mutica*)

Common name: Water grass, Buffalo grass, Mauritius grass, Angola grass, California grass

Plant characters This grass is a coarse trailing perennial, rooting at the nodes with ascending flowering stems even upto 2.5m high.

Origin and Distribution:

Though it is a native of tropical Africa and tropical south America (Brazil), it is widely distributed as a fodder grass in tropical and subtropical areas of the world. It grows well on moist soils (a water loving grass) and withstand prolonged flooding or water logging, bur makes little growth during dry weather. More suited for water inundated condition and sewage farms. It can be used for green soiling, hay and should be grazed rotationally as it will not withstand heavy grazing.

Climate and soil:

Grows well in areas with Rainfall 1000-1500 mm., with optimum temperature is around 15-38ºC. Can tolerate water logging and most suitable for marshy areas. Comes up well in sewage water. But sensitive to cold and frost. Semi-aquatic grass grows well in rice growing areas of world. Highly tolerant to saline and sodic soils and used for reclamation of saline soils than any other grass.

Land preparation: It needs thorough land preparation plough the field 4-6 times followed by harrowing. Then made into ridges and furrows.

Season:

In irrigated condition throughout the year it can be sown suitable time for kharif is June -

July or the onset of spring. In rabi conditions growth is very poor. Summer: as it is water

loving crop summer crop cultivation is rare phenomenon.

Seeds & sowing:

Propagated by seed, rooted slips and runners/ stem cuttings.Seed setting is poor and has dormancy. So mostly propagated by rooted slips and runners. In summer, rooted slips are safer than runners.Seed rate- 2.5-3.0 kg/ha.Transplanting method- 40,000-50,000 rooted slips/ha or 2-4 q/ha planting material is required. Spacing is 50cm × 50 cm. planting should be done to a depth of 3cm on the side of the ridge.

Manures & Fertilizers:

Apply 25 t/ha of FYM or compost after the second ploughing. The rcommended nitrogen (20kg/ha), phosphorus (40kg/ha) and potassium (20kg/ha). Should be applied in band prior to the sowing is. Top dressing of nitrogen 20kg/ha after each harvest.

Irrigation:

Irrigate immediately after sowing and give light irrigation on the 3rd and thereafter can be irrigated as and when depending upon the requirement of crop.

Weeding:

Hand weeding or hoeing and weeding on the 30th day should be practiced. 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 simultaneously.

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Harvesting and yield:

The crop is ready for the first cut in the three months after the planting and subsequent cutting can be taken at an interval of the 30-35days. Para grass is reported to have yielded 200-240 t/ha/year.

Guinea grass (*Panicum maximum*)

Plant characters:

The grass is a tall, densely tufted perennial, with numerous shoots arising from the short stout rhizomes. A full grown plant attains a height of 1.8 to2.7m under favourable conditions. Culms are erect ,glabrous, nodes densely hairy, leaf blades are about 60cm long. The inflorescence is an open panicle ,about 30cm long

Has a variable species. Depending on agronomic characters like habit, height, stem thickness, degree of branching etc. They may be identified into two distinct types

i) Large or medium types suitable for soilage and grazing.

ii) Small or low growing types mainly suitable for grazing.

Origin and Distribution:

This grass is native of tropical Africa. Introduced in our country in 1798. It is one of the oldest introduced grass in our country.

Climate and soils:

The grass thrives best in warm moist climates with annual rainfall 600-100 mm. Tolerates drought fairly wells but susceptible to frost. Frost burns the plant tips and leaves rapidly loose their succulence and stems become hard and dry. Optimum temperature is 15-38^{0}C.Best grass suits under orchards or forestry trees because of shade tolerance ability.

Adopted to wide range of soils except water logging and acidity, can tolerate medium salinity Fertile of well drained medium loamy soils are most suitable. Can be grown along the field bunds and sides of irrigation channels to prevent erosion.

Land preparation

Thre land is prepared by giving 1-2 ploughings, fallowed by 3 to 4 harrowings.

Varieties:

The following are some of the commercial varieties of large or medium types.

1) Queensland common: East African Origin. It is a well-tillered buchy type grows to 150 cm height. Stem nodes are hairy and finer leaf sheath and blades.

2) Rivers dale: is a selection from 9 C made by South Johnstone Research Station at Riversdale.

3) Makueni: Drought resistant one. Grows to a height of 1 m in height and light green in colour.

4) Gatton panic: is a medium type variety. Easily distinguished from Queensland guinea, as the stem nodes are smooth. Resistant to grazing and creates less management problems.

5) Hamil: very tall variety of guinea grass. Robust, smooth, erect that grows from 3 to 3.5 m hight. Foliage is dark green than Riversdale and Makueni and stem nodes are free of exposed hairs. Well accepted by animals.

6) Colonial guinea: Very palatable type but less productive than other guinea grass varieties. Very tall variety growing upto 3 m. Practically hairless and thick fleshy stems. Well accepted by cattle. The foliage is blue green and flowers later than other varieties due to long growing season. Very drought resistant.

Small types: Green panic or slender guinea var. (trichoglume). This is a French grass has an ascending habit crown expanding by short horizontal stems. It shows drought resistance and survives well in situations where Rhodes grass dries at completely. Leaves are fine and soft and stems are slender. Has a good (unique) regenerative capacity and most responsive to improved fertility.

Season :

In South India under irrigation conditions all months are suitable Except in Dec-Jan. Under rainfed condition it is sown during June-August. In North India Mid Feb-August is favourable under irrigated conditions.

Seeds & sowing :

Propagated by seed, rooted slips and stem cuttings. In summer Root stocks are safer than stem cuttings. seeds may be broad casted in the nursery bed and seedlings transplanted in the field with the break of the monsoon. Straw mulching can improve the establishment. 4-10 kg seed/ha under direct seeding, 2-3 kg/ha for transplanting, 40,000-45,000-stem cuttings/ha. Or 66,000 rooted slips are sufficient spacing is 50 x 30 cm or 90 x 45 cm. Seeds have to be stored for more than six months before sowing for breaking dormancy. Plant the rooted slips to a depth of 3cm on the side of the ridge or sow the seeds on the marked lines or raise seed in nursery and transplant 20-25 days after germination.

Fertilizers:

The grass responds well to manuring. To ensure high yields a basal dose of 10-15 t FYM/ha or compost after the second ploughing should be incorporated. The rcommended doses of nitrogen 50kg/ha, phosphorus 50kg/ha and potassium 40kg/ha should be applied in band prior to the sowing. Repeat the basal application once in a year for sustained higher yields.Top dressing of nitrogen 25kg/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.

Harvesting & **Yield**:

The first cut can be taken in six to eight weeks after planting . The average production is about 200-250t/ha/yr in 7-8 cuttings. The yield however, declines with age and it is advisable to replant the field with fresh slips every fifth year. The replanting can be done in the standing field of guinea grass in between the rows and the old plants removed after the new plants get established. The fodder supply can thus be maintained at an uniform level.

Major cropping systems:

Legumes should be grown along with guinea or rotated.

Australia – Centro and Stylo Desmodium

North India – Berseem, Senji, peas.

South India – cowpea, guar or rice bean, Lucerne. Under humid-red soil conditions guinea grass is grown under coconut garden.

Toxicities:

Heavy N fertilization Causes nitrate toxicity.

Small levels of HCN % is also noticed

Panicum sps. Contain Heptotoxins which may cause secondary photo sensitization. Animal with white skin or with white patches usually suffer from the disease.

Remedy: - Affected animal may be given chlorophyll free diet and kept in darkness for a few days till recovery.

Lecture No.31

Introduction- Origin, distribution,soils,land preparation-varities,seasons – seeds&sowing,fertilizer,irrigation,weed management,harvesting,yield and major cropping systems of Berseem *(Trifolium alexandrium)*

Common name: Egyptian clover.

Plant characters:

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

Origin and distribution :

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

Climate and soil:

Grows in tropics, subtropics and temperate regions.Temperature range is 25-35^{0}C optimum for seedling growth. 15-20^{0}C optimum for vegetative growth and branching. 35-37^{0}C optimum for flowering and seed setting. It cannot tolerate frost temperature below 4-5 ^{0}C.Well drained deep loamy soils rich in lime, P, K with PH5.5-8.5 are recommended. Do not perform well on sandy soils, water logging and acidic soils. Can tolerate salinity, alkalinity and is thus useful for reclaiming brackish and alkaline lands.

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

Varieties:

Mescavi: varieties under this group develop short side branches at the base of the stem in advanced stage of its growth. When the plant is cut or harvested, these branches elongate and produce new growth. Therefore it is possible to take 5-6 cuts per year from this group. Varities: Wardan, JB-1, JB-2, JB-3, UPB-103.

Fahl : develop small side branches in the upper portion of the stem very freely. They donot produce branches at the base. Therefore there is no regeneration of these varities after harvest. They give only one cut.

Saidi: They develop shoots for a short time. Develops branches at the upper portion less freely than in Fahl. They give 2-3 cuts per year. Ex: Khandwari, Pusa giant, IGFRI-99-1, IGFRI-54, Jawahar.

Season:

It is a rabi season crop. October to November sowings are adopted depending on prevailing temperatures and vacation of kharif crop.

Seeds & sowing:

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

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

Seed treatment: Seed should be treated with 10% brine (salt) solution to remove the seeds of chicory. Scarified against hard surfaces to soften the seed coat for better germination. Seed is soaked in water for 10-12 hrs or in diluted H_2SO4 for 2-3 minutes and then rinsed with water 4-5 times.10% jaggery solution 1.25 kg with 1.25 litres of water is prepared by boiling and cooling to the room temperature. Then mix with 1.25 kg Rhizobium trifoli bacterial culture which has 10^7 to 10^9 cells of bacteria per gram. Sprinkle the culture on the seed uniformly and dry under shade. Mix the seed with 10 kg soil and broadcasted or drilled in the field.

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

Manures & Fertilizer:

Berseem response well to manuring and need about 10 t FYM /ha, 25 – 30 kg N, 80-100 kg P_2O_5, 30-40 kg K_20 kg /ha P is applied as SSP and K as MOP.½ N, total P and K as basal and remaining ½ N should be applied 30 DAS. Micronutrient deficiencies are common with regard to B, Mo, Fe and Zn and has to be corrected. Boron deficiency is very common in coarse textured and leached out soils. Its deficiency causes several pale yellow spots on the leaves which resemble the leaf hopper damage. Corrected by foliar application of 0.1% borax or soil application of borax @10 kg/ha as basal And Mo as Ammonium molybdate @1- 1.5 kg/ha.

Irrigation:

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

Weeding :

Requires thorough weeding in initial stages. ***Chicorium intybus*** is associated weed of berseem. Remedy is soaking in the 10% brine solution for 10-15 minutes, seeds floating on the water are removed with supplemental hand weeding at 30 DAS. Do not allow the weed to set seed. The seed live in the soil for a long time.Chemical treatment**:** 0.75 -1.0 kg a.i. /ha pendimethalin, as pre emergence herbicide is recommended. Incidence of Cascuta is also noticed.

Harvesting:

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

Yield: 35-55 tonnes/ha/year in / 4-6 cuttings.

Toxicities:

Bloat or Tympanitis: Occurs due to the presence of 4-5% cytoplasmic proteins which act as foaming agent. Accumulation of gases is an important disorder due to fermentation process.

Remedy:

1) Punching the stomach with an instrument called Tracer and canula.
2) Administration of Prolaxalin @ 10-20 g/kg body weight. of animal.
3) Mixing the seed with linseed / mustard oil.
4) Early morning grazing on berseem should be avoided as dew fall on the berseem accentuates the bloat problem in animals.

Cropping systems :

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

Lecture No.32

Introduction- Origin, distribution,soils,land preparation-varities,seasons–seeds&sowing,fertilizer,irrigation,weed management,harvesting,yield and major cropping systems of Lucerne *(Medicago sativa)*

Common name: Alfalfa/ snail clover/Chilean clover

It is regarded as QUEEN OF FORAGE crops.

Also called as GREEN GOLD of forage crops.

Alfalfa is an Arabic word means ‘the best’

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Plant characters and uses :

A Perennial bushy herb and growing to height of 1.6 m with upright or decumbent and quadrangular stem. Trifoliate leaves with fast and quick growth habit. Seed is kidney shaped greenish yellow color. Readily accepted by all animals especially horses.

CP: 18-21%

DCP: 15%

TDN: 58%

Origin:

It was originally a native of South western Asia.. It was introduced to India in the year 1900.

Climate and soil:

Comes up well in tropics, sub tropics and temperate regions upto 2400m above MSL. Temperature in the Range of 15-25^{o}C- day time10-20^{o}C -night time, 20-30^{o}C is required for seed set 15-20^{o}C is optimum for vegetative growth.

Well drained deep loamy soils rich in lime N, P, K with pH 5.5-8.5 are optimum . Do not perform well on sandy soils. Can tolerate drought but not water stagnation and high humidity. Remains dormant under conditions of drought and resume the growth in the availability of water in the soil. Acidic soils are not suitable. Root growth is stunted due to less conc of Ca, S and Mg, can thrive on alkaline soils two.

Land preparation:

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

Varieties:

Annual varieties: Anand-1,2,3, LLC-3, RCL-87-1 & LLC -5.

Perennial: CO-1, T-9 or sirsa-9, Sirsa-8, RL-88, sri ganga sagar, IGFRI-s-244 (chetak), alamdar-1 & IGFRI –S-54.

Season:

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

Seeds & sowing:

A seed rate of 20 kg/ha in line sowing, 30.kg/ha in broadcasting would be sufficient.

Spacing : crop is sown 25-30 cm apart in solid rows.

Seed treatment: Seed should be treated with 10% brine (salt) solution to remove the seeds and inert material. Scarified against hard surfaces to soften the seed coat for better germination. Seed is soaked in water for 10-12 hrs or soak in diluted H2SO4 for 2-3 minutes and then rinse with water 4-5 times. and cooling to the room temperature. Then mix with 1.25 kg Rhizobium seed should be treated with recommended rhizobium culture for nitrogen fixation. If sown first time in the land.

Manures and Fertilizer:

Lucerne respons well to manuring which needs about 25 t FYM /ha, 25 – 30 kg N, 120 kg P_2O_5, 40 kg K_20 /ha. P is applied as SSP and K as MOP.½ N, + entire applied and remained P and K as basal which are, ½ N at 30 DAS. Micronutrient deficiencies are common with regard to B, Mo, Fe and Zn to be corrected.

Weeding:

Require thorough weeding in the initial stages. Cuscuta is a complete stem parasite. Remedy is uproot the plants along with host plants and burnt. Do not allow the weed to set seed. The seed will live in the soil for a long time. Cultivation of Lucerne should be avoided in fields once infested with cuscuta at least for 3 years.

Chemical treatment: 0.75-1 kg Pendimethalin as pre emergence herbicide or imazethpyr @ 100 g/ha as early post emergence (10-12 days).

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

Harvesting & Yield:

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

Cropping systems : N-B hydrid + guar – Lucernr under semi arid conditions or it is taken as inter crop with N-B hybrid.

Toxicities:

1) Bloat or Tympanities: occurs due to the presence of 4-5% cytoplasmic proteins which acts as foaming agent. Accumulation of gases is an important disorder due to fermentation process.

Remedy:

1. Punching the stomach with an instrument called tracer & canula.
2. Administration of prolaxin @ 10-20 g/kg body wt. Of animal.
3. Mixing the feed with linseed/mustard oil.

2) Isoflavonoides of oestrogen cause reproductive disorders due to production of excess heat in the animal body.

Remedy: by the addition of concentrated feed the severity can be reduced.

3) **Dermatitis or photosensitization:** caused due to histamines. The symptoms are inflammation of the skin like reddening, swelling, oozing, scaling mostly in the white skinned animals.

Remedy: keeping the animal under shade & stall feeding.

4) Saponins: are the glucosides present in roots, stem, leaves and flowers of lucerne. Cause haemolysis of blood and reduces egg production. Saponins are more concentrated in young stages and reduces in maturity stage.

Symptoms: Bitter in taste and reduced cholesterol levels which Causes hypoglycaemia of RBC and foam will be oozed out from mouth.

Remedy: supplementing mild strains of saponins containing feed.

Supplying 1% cholesterol to animal.

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