PRACTICAL MANUAL

CROP PRODUCTION TECHNOLOGY - I (*Kharif* Crops)

APA 204 2(1+1)

For B. Sc. (Agriculture) II-Year (3rd Semester)

2020

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Syllabus: Crop production technology – 1 (*Kharif* crops) APA 204 2(1+1)

PRACTICAL: Rice nursery preparation, transplanting of Rice, sowing of soybean, pigeon pea and mungbean. Maize, groundnut and cotton: effect of seed size on germination and seedling vigour of *kharif* season crops. Effect of sowing depth on germination of *kharif* crops, identification of weeds in *kharif* season crops, top dressing and foliar feeding of nutrients, study of yield contributing characters and yield calculation of *kharif* season crops, study of crop varieties and important agronomic exercises at farm. Study of forage Exercises, morphological description of *kharif* season crops and visit to research centres of related crops.

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Roll No. : ….…………...

Batch: ………………...

Session: ………………..

Semester: ………………..

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Date: Course Teacher

INDEX

PRACTICAL NO. 1

OBJECTIVE: To study methods of rice nursery preparation

Wet bed:

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Modified mat nursery: ……………………………………………………………………………

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How to prepare seedlings for mechanical transplanting: ……………………………………………………………

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Exercise:

1. The student will grow various type rice nursery.
2. Compare among wet, dry and dapong nursery bed preparation.

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PRACTICAL NO. 2

OBJECTIVE: To study method of rice transplanting

Date of transplanting: ……………………………………………………………………………………………………

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Age of seedlings at transplanting: …………………………………………………………………………………

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Uprooting of seedlings: ……………………………………………………………………………………………

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METHOD OF TRANSPLANTING:

Flat puddled transplanting: ………………………………………………………………………………………

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Bed transplanting: ……………………………………………………………………………………………………

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Exercise

1. The student will practice rice transplantation.
2. Compare between manual and mechanical transplanting.
3. Write about SRI method of rice transplanting

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PRACTICAL NO. 3

OBJECTIVE: To study sowing methods of *Kharif* crops

Define different methods of sowing of crop in field and show diagrammatically along the methods also briefly.

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PRACTICAL NO. 4

OBJECTIVE: To study sowing of soybean, pigeonpea, mungbean, maize, groundnut and cotton

PARAMETERS	MAIZE	SOYBEAN	GROUNDNUT	PIGEON PEA	MOONG BEAN	COTTON
Spacing (cm)						
Sowing Depth (cm)						
Season/ Time of Sowing						
Sowing Method						
Seed Rate (kg/ha)						
Seed Inoculation						

Exercise

1. The student will identify different sowing methods of cereals, legume and oilseeds.
2. Enlist various agronomic measures under sowing management.

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PRACTICAL NO. 5

OBJECTIVE: To study effect of seed size on germination and seedling vigour of *Kharif* season crops

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Exercise

1. The student will identify different seed of cereals, legume and oilseeds.
2. Take seed index and test value of various crop seeds.
3. Calculate germination percentage with tetrazolium test.
4. See the effect of seed size on germination percentage.

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PRACTICAL NO. 6

OBJECTIVE: To study effect of sowing depth on germination of *Kharif* crops

Sowing Depth: ……………………………………………………………………

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Exercise

1. The student will identify different seed sowing depth of cereals, legumes and oilseeds.
2. Write ideal sowing depth of *Kharif* cereals, legumes and oilseeds.
3. Make a list of sowing depth of *Kharif* season crops.
4. See the effect of sowing depth on germination percentage.

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PRACTICAL NO. 7

OBJECTIVE: To study common weeds of *Kharif* season crops

CROPS	MONOCOTS	DICOTS	SEDGES
RICE			
MAIZE			
SORGHUM			
PEARL MILLET			
SOYBEAN			
GROUND NUT			

PIGEON PEA			
MOONG BEAN			

PRACTICAL NO. 8

OBJECTIVE: To study top dressing and foliar feeding of nutrients

Top dressing: ………

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Soil application: ……………………………………………………………………………………………………

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Foliar Feeding: ……………………………………………………………………………………………………

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Advantages of foliar feeding:

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Nutrient	Source	Foliar application (Kg/ha)
Boron		
Copper		
Iron		
Manganese		
Molybdenum		
Zinc		
Calcium		

Nutrient	Source	Foliar application (Kg/ha)
Magnesium		

Fertilizer:

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Types of fertilizers: ……………………………………………………………………………………

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PRACTICAL NO. 9

OBJECTIVE: To study top dressing and foliar feeding of organic nutrients sources

Organic manures:

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IMPORTANT ORGANIC MANURES

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PRACTICAL NO. 10

OBJECTIVE: To study top dressing and foliar feeding of biofertilizers sources

Biofertilizers: ……………………………………………………………………………………………………

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Exercise

1. The student will identify different fertilizers and collect them.
2. Work out the fertilizer requirement for a ploy of 10000 m^2 if the recommendation of fertilizers for oat crop are 100 kg N and 30 kg P_2O_5 /ha and source of fertilizers are DAP and urea. Also suggest the method and time of application of fertilizer in this crop.
3. Classify the different types of fertilizer in detail.
4. Identify the given manures and fertilizers and write their nutrient content.

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PRACTICAL NO. 11

OBJECTIVE: To study yield contributing characters and yield calculation of *Kharif* season crops

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Exercise

1. The student will calculate yield of cereals, legumes and oilseeds.
2. Calculate harvest index of *Kharif* cereals, legumes and oilseeds

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PRACTICAL NO. 12

OBJECTIVE: To study yield attributes and calculation on theoretical yield and harvest index

Question for students

Find out the yield of jute fibre in (q/ha) from the following details

Spacing- 25 cm x 10 cm Average wt. of matured plant- 75 g (at green stage)
Extractable fibre --- 8% (Ans- 24 q/ha)

Solution: ……………………………………………………………………………………………………

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2. What would be the yield of jute seed if the following details are given:

Spacing- 25 cm x 10 cm Test wt. of seed- 6 g
Average no. of seed/plant-170 (Ans - 4.08 q/ha)

Solution: ……………………………………………………………………………………………………

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3. Estimate the yield of groundnut pods, kernels and oil from the following data:

Spacing- 45 cm x 20 cm
Average no. of matured pods/plant-24
No. of kernels/pod-2
Test weight of kernels-620 g
Shelling percentage-70
Percentage of oil in kernels- 45

(Ans- 30.6 q/ha kernels, 42.9 q/ha unshelled pods, 13.77q/ha oil yield)

Solution: …………………………………………………………………………………………

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4. Estimate the seed yield (q/ha) of mungbean based on following data:

Spacing --- 30 cm x 12 cm
Average no. of pods/plant - 25
Average no. of seeds/pods - 6
Test wt. -- 32 g

Solution: …………………………………………………………………………………………

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PRACTICAL NO. 13

OBJECTIVE: To study various crop varieties and important agronomic experiments at experimental farm

CROPS	VARIETIES
✓ Rice	
✓ Maize	
✓ Sorghum	
✓ Bajra	
✓ Finger millet	
✓ Soybean	
✓ Groundnut	
✓ Pigeon pea	
✓ Moong bean	
✓ Urd bean	
✓ Cotton	
✓ Jute	

AGRONOMIC EXPERIMENTS:

SOWING MANAGEMENT:

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Exercise

1. The student will make list of *kharif* cereals, legumes and oilseeds varieties.
2. Learn about various agronomic practices of cultivation.

PRACTICAL NO. 14

OBJECTIVE: To study of forage crops

Kharif **Fodders**

English Name	Common Name	Scientific Name
Non-leguminous		
Pearl millet		
Maize		
Sorghum		
Teosinte		
Leguminous		
Cowpea		
Cluster bean		
Soyabean		

Rabi Fodders

Non-leguminous		
Mustard		
Mustard (Indian)		
Chinese cabbage		
Turnip		
Turnip		
Carrot		
Leguminous		
Egyptian clover		
Indian clover		
Fenugreek		

Perennial Fodders

Lucerne		
Napier grass		

Grasses

Napier grass		
Guinea grass		
Para grass		
Sudan grass		
Dina grass		
Anjan grass		
Doob grass		
Setaria grass		
Rhodes grass		

Tree

Khejri		
Subabool		

PRACTICAL NO. 15

OBJECTIVE: To study morphological description of *Kharif* season crops

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PRACTICAL NO. 16

OBJECTIVE: To study harvesting of different *Kharif* season crops

1. Write down method and material required for harvesting of different *kharif* season crops.

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PRACTICAL NO. 17

OBJECTIVE: Visit to research centers of related crops

1. Students may have to visit a nearby Indian Grassland and Fodder Research Institute, Jhansi.
2. Make a list of crops grown in the farm, group them into cereal, legume and oilseed.
3. Try to familiarize yourself with the identification of fodders. Learn the local practices of cultivating those fodders.
4. To know about scope of fodder and forage in Bundelkhand region.

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PRACTICAL NO. 18

OBJECTIVE: Visit to research centers of related crops.

1. Students may have to visit a nearby Central Agro forestry Research Institute center, Jhansi.
2. Make a list of crops grown in the farm, group them into cereal, legume and oilseed.
3. Try to familiarize yourself with the identification of alley crops & learn the local practices of cultivating those crops.
4. To know about scope of agro forestry in Bundelkhand region.

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APPENDICES

RICE NURSERY PREPARATION

Wet bed: Use this method in areas with sufficient water supply. Area of 1/10 of the field is essential, and 40 kg of seed can be transplanted 1 ha of land.

- Prepare beds at 1 m wide by convenient length with raising the soil height at 5−10 cm.
- Broadcast pre-germinated seeds in thoroughly puddled and leveled soil.
- Construct drainage channels for proper water removal.
- Add organic manure (Farm yard manure) and a small amount of inorganic fertilizer as basal dressing. This increases seed vigor and allows easier uprooting for transplanting.
- Transplant age of seedlings is 2-3 weeks old.

Dry bed: Nursery is prepared in dry soil conditions. The site should be free from shade and has to be accessed to irrigation facilities. Area of 1/10 of the field is essential, and 60−80 kg of seed can be transplanted 1 ha of land.

- Preparation of beds must be done at 1 m wide length while maintaining soil height at 5−10 cm.
- Distribution of a layer of half burned paddy husk should be kept on the nursery bed to facilitate uprooting.
- Prevent moisture stress by irrigation. Without appropriate moisture, roots may be damaged during pulling.
- If nutrient supply is low, apply basal fertilizer mixture and incorporate it between rows.
- Transplant seedlings at 2-3 weeks old.

Dapong method: Dapong or mat method is most appropriate for growing short duration varieties, as seedlings experience less transplanting shock. Preparation of dapong nurseries is applicable where a flat firm surface is available and water supply is very reliable. Allot 100 m^2/ha or 1% of the field for the seedbed, and prepare 40−50 kg of seed per ha. Compared to other methods, this requires less labor, and has minimal root damage.

- Mark out 1 m wide and 10−20 m long plots.
- Cover the surface with banana leaves, plastic sheets, or any flexible material from penetrating the bottom layer of the soil. Cemented floors may also be used as base. Form the boundary with bamboo splits or banana sheath.
- Cover the seedbed with about 1 cm of burned paddy husk or compost.
- Sow pre-germinated seeds on the seedbed. Maintain a thickness of 5−6 seeds (1 kg per 1.5 m^2).
- Sprinkle water to the seeds after sowing, and then press down by hand or with a wooden flat board.
- Transplanting age of seedlings is 9−14 days old.

Modified mat nursery: The modified mat nursery uses less land and requires fewer seeds and inputs (i.e., fertilizer and water). Allot 100 m^2/ha for the seedbed, and prepare 18−25 kg of good quality seeds.

- Cover the surface of 4 cm layer soil mix with banana leaves, plastic sheets, or any flexible material from penetrating the bottom layer of the soil.
- Sow pre-germinated seeds on the seedbed, then sprinkle with water. Maintain a thickness of 2−3 seeds.
- Water the nursery 2 times a day for 5 days.
- Transplant seedlings at 15−21 days old, when seedlings reach the four-leaf stage.

How to prepare seedlings for mechanical transplanting: Mechanical transplanting requires skilled labors and mechanical transplanter. Machanical transplanting saves time, labor and money. Mechanical transplanters have built-in trays or seedling boxes. Grow seedlings on a thin layer of soil in 30 cm x 60 cm trays per seedling box. In some instances, seedlings are grown on larger areas and then cut into rectangular strips (mats of seedlings) that fit into the planting trays of the transplanter.

TRANSPLANTATION OF RICE

Dates of Transplanting: Time of transplanting is a single factor which influences rice yield substantially. For getting maximum yield of rice and for the timely vacation of the field for sowing wheat and other crops adopt the following transplanting schedule: Second fortnight of June PR- 120, PR 118, PR 116, PR 114, PR 113 and PR 111 Under late sown conditions PR 115

Age of Seedlings at Transplanting: Start uprooting the nursery when the seedlings become 25 to 30 days old. As the transplanting proceeds, use seedlings from the same nursery sown in May. Seedlings older than 30 days upto 55 days give better yield under late transplanting for long duration varieties. However, in short duration varieties seedlings of 25-30 days should be preferred.

Uprooting of Seedlings: Irrigate the nursery before uprooting. Wash the seedlings in water to remove mud.

Method of Transplanting:

Flat puddled transplanting: Transplant seedlings in lines at 20 x 15 cm (33 hills/m^2) for normal and 15 x 15 cm (44 hills/m^2)

for the late transplanting. Put 2 seedlings per hill. The seedlings should be transplanted upright and about 2-3 cm deep. This practice ensures good establishment of seedlings and early tillering, which are essential for good tiller development and synchronous flowering.

Bed transplanting: Transplant 30 days old seedlings on the middle of the slopes of beds prepared with wheat bed planter on heavy textured soils. After field preparation (without puddling), apply basal dose of fertilizer and prepare beds. Irrigate the furrows and immediately transplant seedlings by maintaining a plant-to-plant distance of 9 cm to ensure 33 seedlings/m^2. During the first 15 days after transplanting irrigation water should be allowed to pass over the beds once in 24 hours. Thereafter apply irrigation in furrows only two days after the ponded water has infiltrated into the soil. Every care should be taken that field does not develop cracks in the furrows. In this way about 25 per cent of total applied irrigation water can be saved without affecting the grain yield. For controlling weeds spray Nominee Gold 10 SC (Bispyribac sodium 25 g/ha), Segment (Azimsulfuron 25 g/ha), Granite (Penoxsulam 35 g/ha) as post emergence, 20-25 days after transplanting. Hand weeding of weeds can be done, if needed.

SOWING OF SOYBEAN, PIGEONPEA AND MUNGBEAN. MAIZE, GROUNDNUT AND COTTON

PARAMETERS	MAIZE	SOYBEAN	GROUNDNUT
SPACING (cm)	60-75×25cm (hybrid) 60×20-25cm (composite)	30-7.5×5cm	**Bunch type:** 30×7.5cm (*Zaid*); 30×10cm (*kharif*) **Spreading:** 45×10 cm (*Zaid*) 60×15cm (*kharif*)
SOWING DEPTH (cm)	4-6	3-4	8-10
SEASON/ TIME OF SOWING	Onset of monsoon (*kharif*) 1st week of march (*Zaid*) Oct.-Nov. (*Rabi*)	15th june-1st week of July	Onset of monsoon-1st week of July
SOWING METHOD	Line sowing, dibbling, transplanting (3week old seedling)	Line sowing, BBF (broad bed furrow), Ridge & furrow	Line sowing, Dibbling, FIRB, BBF, Furrow & Ridges
SEED RATE (kg/ha)	20 (composite); 18 (hybrid) 40-45 (green fodder)	70-80	70-80
SEED INOCULATION		*Rhizobium japonicum*	*Rhizobium japonicum*

PARAMETERS	PIGEON PEA	MOONG BEAN	COTTON
SPACING (cm)	60×15 (early) 60-75×15-20 (medium) 75×20 (late)	45×5 (*kharif*) 30×5 (*Rabi* & summer)	**Rain fed:** Desi = 45×45; Hybrid = 90×90 **Irrigated:** Desi = 60×60; Hybrid = 120×120 **Improved varieties**: 75×75
SOWING DEPTH (cm)	5-7	3-4	5-8
SEASON/TIME OF SOWING	15-30 June	*Kharif*, *Rabi, Zaid*	1st fortnight of may (irrigated) Onset of monsoon (*kharif*)
SOWING METHOD	Line Sowing, Dibbling	Line sowing,	Line sowing, Transplanting (8 weeks old seedling)
SEED RATE (KG/HA)	10-12 (short); 12-15 (medium); 15-18 (long)	12-15 (*kharif*) 20-25 (*Rabi* & *Zaid*)	10-15 (Desi); 18-20 (Egyptian cotton) 2-2.5 (hybrid); 1-1.25 (Bt cotton)
SEED INOCULATION	*Rhizobium leguminosarum*	*Rhizobium leguminosarum*	

SEED SIZE ON GERMINATION AND SEEDLING VIGOUR OF *KHARIF* SEASON CROPS

- Seed size is an important physical indicator of seed quality that affects vegetative growth and is frequently related to yield, market grade factors and harvest efficiency.
- Genetic variation is the cause for variation in size of seed between varieties. Based on size, the seeds are classified as very large, large, medium, small and very small. This variation is due to flow of nutrients into the mother plant. Since seed coat and embryonic axis are the first to develop in a seed within a pod and accumulation of food reserve is occur later one. This variation is exerted in size, later on mobilization of food reserve to growing seeding; it has been reflected in many crop species and many verities.
- A wide array of different effects of seed size has been reported for seed germination, emergence and related agronomic aspects in many crop species generally large seed has better field performance than small seed.

- For a successful crop production, the use of good quality seed is very essential which increase the yield by 15.20 %. The extent of this increase directly proportional to the quality of seed that is being sown.

EFFECT OF SOWING DEPTH ON GERMINATION OF *KHARIF* CROPS

Sowing Depth:

- Germination is the process of reactivation of the metabolic machinery of the seeds and the emergence of the radical (root) and the plumule (shoot), leading to the production of a seeding.
- Germination is maximized in any given seed when such seeds are viable, non-dormant and the embryo quiescent (Dutta and Dutta, 2008) Germination marks the beginning of the independent growth and existence of seeds or other organs.
- Arousing a dry seed to commence germination entails inhibition of water, formation of enzyme system, radical emergence and seeding sprouting. The importance of varying planting depths has received lots of attention of researchers, for some time now.
- It was found that planting depths affected seed germination in all studied crops since germination percentages decreased with increasing planting depths with the highest germination rate was obtained at 0 cm (Surface) Planting level.
- Generally, it has been found that lower planting depth favored maximum germination in the crops like maize, rice, beans, groundnut and okra though at different rates while increasing planting depths caused reductions in the germination percentage of such crops.

Ideal planting depth:

- Every seed has a unique depth based on its overall size. In general, a seed planting depth is approximately two to three times its diameter size. Depending on the plant, some seeds need a deep planting location so that subsequent roots grow deeply for solid anchoring. All of the seed's preferred planting depths depends on their natural environment and evolution any development.
- Input which decides plant stand in the field. It influences the germination & Emergence of seed. Sowing should be done at recommended depth. These vary with the kind of seed and its size. Bigger seeds may be sown at greater depth while small sized seeds at shallow. Seed 5/6 drooped in the moist zone. In, *Kharif*, sowing 5/6 shallow and in Rabi deeper except pre sowing irrigation.
- Field Crops normally absorb the majority of nutrients from the soil through root absorption, but above ground plant structures, especially leaves, are capable of absorbing limited amount of some nutrients. Because of this most supplemental nutrient supplied to crops as fertilizer are applied to the soil and soluble nutrients in the soil contact root hair surfaces, where they one absorbed into the roots and transferred to other parts of the growing plant for metabolic use.

IDENTIFICATION OF WEEDS IN *KHARIF* SEASON CROPS

CROPS	MONOCOTS	DICOTS	SEDGES
RICE	*Echinochloa colona* *E. crussgalli* *Cyanodon dactylon* *Commelina benghalensis* *E. glabrescence*	*Eclipta alba* *Ageratum conizoides* *Phyllanthus niruri* *Phyllanthus fraternus*	*Cyperus iria* *Cyperus difformis* *Fimbristylis miliaceae*
MAIZE	*Echinochloa colona* *E. glabrescence* *Cyanodon dactylon* *Eleusine indica*	*Phyllanthus niruri* *Phyllanthus fraternus*	*Cyperus iria* *Cyperus difformis* *Fimbristylis miliaceae*
SORGHUM	*Echinochloa colona E.glabrescence* *Cyanodon dactylon*	*Eclipta alba* *Phyllanthus niruri* *Phyllanthus fraternus*	*Cyperus iria* *Cyperus difformis* *Fimbristylis miliaceae*
PEARL MILLET	*Echinochloa colona* *E.glabrescence* *Digiteria sanguinelis* *Cyanodon dactylon*	*Trianthema portulacastrum* *Phyllanthus niruri* *Phyllanthus fraternus*	*Cyperus iria* *Cyperus difformis* *Fimbristylis miliaceae*
SOYBEAN	*Echinochloa colona E.glabrescence* *Cyanodon dactylon*	*Phyllanthus niruri* *Phyllanthus fraternus* *Solanum nigrum* *Euphorbia geniculata*	*Cyperus iria* *Cyperus difformis* *Fimbristylis miliaceae*
GROUND NUT	*Echinochloa colona* *Cyanodon dactylon* *E.glabrescence* *Dactyloctinium aegyptium* *Eluesine indica*	*Phyllanthus niruri* *Phyllanthus fraternus* *Abutilon indicum* *Celosia argentia* *Digera arvensis* *Anagellis arvensis*	*Cyperus iria* *Cyperus difformis* *Fimbristylis miliaceae*
PIGEON PEA	*Echinochloa colona* *E.glabrescence* *Cyanodon dactylon* *Commelina benghalensis* *Dactyloctinium aegyptium* *Eluesine indica*	*Phyllanthus niruri* *Phyllanthus fraternus* *Digera arvensis* *Euphorbia hirta* *Celosia argentia*	*Cyperus iria* *Cyperus difformis* *Fimbristylis miliaceae*
MOONG BEAN	*Echinochloa colona* *E.glabrescence* *Cyanodon dactylon* *Dactyloctinium aegyptium*	*Phyllanthus niruri* *Phyllanthus fraternus* *Digera arvensis* *Eclipta alba*	*Cyperus iria* *Cyperus difformis* *Fimbristylis miliaceae*

	Eluesine indica	*Euphorbia hirta*	

TOP DRESSING AND FOLIAR FEEDING OF INORGANIC NUTRIENTS SOURCES

Top dressing: The method of application of fertilizer in the standing crops is known as top dressing. The objective of this method is to provide the nutrients, mainly nitrogen, in readily available form, for the growth of plants.

Soil application: Organic manures are mostly spread uniformly in the field and incorporated several days before planting. Following are most important methods of application of fertilizers.

- Broadcasting on the soil surface before ploughing.
- Broadcasting on the soil surface after ploughing and mixing with the surface soil by harrowing.
- Applying fertilizers in a band at the bottom of the plough furrow.
- Applying fertilizers in bands, 5 to 8 or more centimeters from the row and 5 to 8 or more centimeters below the surface.
- A combination of broadcasting methods or plough furrow application with bands at the side of the row to planting time.
- Applying fertilizer with a drill below the surface of the soil before crop is planted.

Foliar Feeding

- It refers to the spraying of fertilizer solutions containing one or more nutrients on the foliage of growing plants.
- Several nutrient elements are readily absorbed by leaves when they are dissolved in water and sprayed on them.
- The concentration of the spray has to be controlled; otherwise, serious damage may result due to scorching of the leaves.
- Foliar app in is effective for the app in of minor nutrients like Fe, Cu, Zn, Mn. Sometimes inserted are also applied along with fertilizer.

Advantages of foliar feeding-

- It reduces weed problems in crop land
- It minimizes cost of production
- It improves plant growth and yield
- It saves labour and time
- It shows quick result in nutrient absorption

FERTILIZER

A chemical or natural substance added to soil or land to increase its fertility. A substance (such as manure or a special chemical) that is added to soil to help the growth of plants. **Fertilizer** is any material of natural or synthetic origin (other than liming materials) that is applied to soils or to plant tissues (usually leaves) to supply one or more plant nutrients essential to the growth of plants.

Nutrient	Source	Foliar application (Kg/ha)
Boron	Borax	2 to 5
Copper	Copper sulfate	2 to 5
Iron	Ferrous sulfate	2 to 3
Manganese	Manganous sulfate	2 to 4
Molybdenum	Sodium molybdate	0.25 to 0.50
Zinc	Zinc sulfate	2 to 4
Calcium	Calcium chloride	5 to 10
	Calcium nitrate	5 to 10
Magnesium	Magnesium sulfate	10 to 15

Types of fertilizers

Straight fertilizers: Straight fertilizer is a fertilizer that contribute single nutrient to the crops e.g., Urea, rock phosphate, ammonia, ammonium sulphate and muriate of potash.

Nitrogenous fertilizer	
Urea	46% N
Calcium ammonium nitrate	25% N
Anhydrous ammonia	82 % N
Ammonium sulphate	21% N
Ammonium chloride	26% N
Urea ammonium nitrate	28-32% N
Phosphate fertilizer	
Single super phosphate	16% P_2O_5
Double super phosphate	32% P_2O_5
Triple super phosphate	48% P_2O_5
Potassic fertilizer	
Muriate of potash	60% K_2O
Sulphate of potash	50% K_2O

Complex fertilizers: Complex fertilizers (also known as compound fertilizers) are made from mixing two or more of macro-nutrient type fertilizers. Complex fertilizers may also be further blended with elements that provide some of the less-common plant nutrients (known as secondary or trace nutrients, such as sulphur, calcium and magnesium) e.g., Di ammonium phosphate (DAP), Ammonium phosphate, Nitro phosphate and NPK.

Di-ammonium phosphate:	18% N and 48% P_2O_5
Ammonium phosphate	20% N and 20% P_2O_5

NPK complex fertilizer

N	P	K
10	26	26
12	32	16
14	28	14
20	10	10

Mixed fertilizers: Mixed fertilizer means a commercial fertilizer containing any combination, blend, or mixture of fertilizer materials designed for use or claimed to have value in promoting plant growth.

Fertilizer Mixtures: When two or more fertilizers are mixed together to supply two or three major elements i.e., N, P_2O_5 and K_2O is known as fertilizer mixture e.g., Ammonium phosphate (20% N and 20% P_2O_5)

TOP DRESSING AND FOLIAR FEEDING OF ORGANIC NUTRIENTS SOURCES

Organic manures: Manure is organic matter, mostly derived from animal faeces except in the case of green manure, which can be used as organic fertilizer in agriculture. Manures contribute to the fertility of the soil by adding organic matter and nutrients, such as nitrogen, that are trapped by bacteria in the soil.

Bulky organic manure: They are bulky in nature but supply nutrients in small quantities are known as bulky organic manure. e.g., Farm yard manure, compost, green manure etc.

Concentrated organic manure: Those which contain higher percentage of major plant nutrient are termed as concentrated organic manure e.g., Oil cake, blood meal, bone meal, fish meal and poultry manure.

IMPORTANT ORGANIC MANURES

Farm Yard Manure:

- It is a mixture of cattle dung, urine, litter or bedding material, portion of fodder not consumed by cattle and domestic wastes like ashes etc. collected and dumped into a pit or a heap in the corner of the backyard. It is allowed to remain there and rot till it is taken out and applied to fields.
- Well rotten farm yard manure (FYM) contains 0.5 % N, 0.2 % P_2O_5 and 0.5 % K_2O major nutrients and huge amount of minor nutrients.

Compost:

- Well-rotted plant and animal residue is called compost.
- Composting means rotting of plant and animal remains before applying in fields. The essential requirements of composting are air, moisture, optimum temperature and a small quantity of nitrogen.
- It is an activity of micro-organisms which convert compound organic materials in simple form by producing various enzymes.

Green Manuring:

- Green manure crops are grown in the field itself either as a pure crop or as an intercrop with the main crop and buried in the same field.
- The most common green manure crops are sunhemp, dhaincha and guar.
- Tender green-twigs and leaves are collected from wastelands which are spread in the field and incorporated into the soil.
- Shrubs and trees are also cut and turned into the soil e.g., Shrubs like *glyricidia*, *sesbania*, karanj.

TOP DRESSING AND FOLIAR FEEDING OF *BIOFERTILIZERS* SOURCES

Biofertilizers: The biofertilizers containing biological nitrogen fixing organisms are of utmost importance in agriculture.

Advantages of *Biofertilizer*

- They help in the establishment and growth of crop plants and trees.

- They enhance biomass production and grain yields by 10-20 percent.
- They are useful in sustainable agriculture.
- They are suitable in organic farming.
- They play an important role in Agroforestry/Silvi- pastoral system.

Types of Bio *fertilizers*:

Rhizobium: Most widely used *biofertilizer* is Rhizobium which colonizes the roots of specific legumes to form tumour like growths called root nodules. These nodules act as factories of ammonia production. Rhizobium – legume association can fix up to 100-300 Kg N/ha in one crop season.

Azotobacter: Application of *azotobacter* has been found to increase yield of wheat, rice, maize, pearl-millet and sorghum by 0-30%. These organisms are also capable of producing antifungal and antibacterial compounds, hormones etc.

Azospirillum: Certain micro-organisms like bacteria and blue green algae have the ability to use atmospheric nitrogen and transport this nutrient to the crop plants. Azospirillum is inoculated to maize, barley, oats, sorghum, pearl millet and forage crops. It increases grain productivity of cereals by 5-20%, of millets by 30% and fodder by over 50%.

Blue-green algae: The utilization of blue green algae as a bio fertilizer for rice is very promising. A judicious use of these algae could provide to the country's entire rice acreage as much nitrogen as obtained from 15-17 lakh tonnes of urea. Algae also helps to reduce soil alkalinity.

Azolla: A small floating water form Azolla is commonly seen in low land fields and in shallow fresh water bodies. These fern harbours a blue-green alga. *Anabaena azollae*. The Azolla – Anabaena association is a live floating nitrogen factory using energy from photosynthesis to fix atmospheric nitrogen accounting to 100-150 kg N/ ha / year from about 40 – 60 tonnes of biomass.

Mycorrhizae: It is the symbiotic association of fungi with roots of vascular plants. It is useful in increasing phosphorus uptake e.g., in fruit crops like citrus, papaya.

Vermi-compost: It is the method of making compost with the use of earthworms, which generally live-in soil, eat bio-mass and excrete it in digested form. Compost is generally called vermi-compost or wormi-compost. It is estimated that 1800 worms which is an ideal population for one sq. meter can feed up to 80 tonnes of humus per day.

YIELD CONTRIBUTING CHARACTERS AND YIELD CALCULATION OF *KHARIF* SEASON CROPS

There are various growth parameters and yield attributes.

GROWTH ATTRIBUTES OF ANY CROP:

- Plant height (based on crop duration)
- Number of leaves (based on crop duration)
- Number of branches
- Number of root nodules
- Stem length (taken from crown portion to top)
- Stem diameter

YIELD ATTRIBUTING CHARACTERS:

- Number of tillers
- Number of filled spikelet /plant
- Number of grains/seeds/plant
- Grain weight (seed index or test weight)
- Seed/grain yield or straw/stover yield
- Harvest index {(grain yield*100)/ (grain + straw yield)}

SOLVED EXAMPLE: If there are 39 plants of paddy and the spacing is 20*15cm. Number of spikelets per plant is 100. Number of grains per spikelet is 25g. The test weight is 25 g. Calculate the yield of paddy in quintal/ha.

Solution: Number of plants = 39

Yield = {(no. of plants*no. of tillers*no of pods*no. of seeds*test weight) / (total area*1000)}

Therefore,

Yield = (39*83*100*25*25*10000)/ (20*15*1000)

= 6743.75kg/ha

= 67.4375q/ha

CROP VARIETIES AND IMPORTANT AGRONOMIC EXPERIMENTS AT EXPERIMENTAL FARM

CROPS	VARIETIES
✓ Rice	Jaya, IR-8, DRR-H2, APHR-1
✓ Maize	Ganga-1, Amber, Deccan, African tall, Proteina, Ratan, Shakti
✓ Sorghum	CSH-1, CSV-1, RSV-53, J-69
✓ Bajra	HB-1, PHB-10, PHB-47
✓ Finger millet	Co-1, AKP-1, Poona, Kaveria, B-1, Sarda
✓ Soybean	Bragg, Lee, Clark-63, Ahilya-4
✓ Groundnut	Tnv-2, election-206, Faizapur, Punjab-1
✓ Pigeon pea	Prabhat, ICPH-8, asha, mukta
✓ Moong bean	Pusa Vaisakhi, sheela, varsha, t-44
✓ Urd bean	Pant variety-19, t-9, Sharda, Neelam
✓ Cotton	Sanjay, Shyamli, MCV-5, Digvijay
✓ Jute	Sabuj Sona, Baisakhi Tosa, JRO-620

AGRONOMIC EXPERIMENTS:

SOWING MANAGEMENT:

Sowing time: For *kharif* season crops we do so during onset of monsoon. Before sowing, we prepare the field by 3-4 ploughing as needed accordingly. In summers, one deep ploughing is done.

Sowing method: Line sowing, dibbling are common sowing methods are also taken into consideration.

Seed rate: Seed rate varies as per sowing time as well as according to seed size and varieties have also have a great impact on seed rate e.g., hybrids have low seed rate.

Spacing: Spacing is utmost required as per plant seed size, their nature *etc.*

Sowing depth: Generally, all *kharif* pulse crops show epigeal germination except pigeon pea, and all *Rabi* pulses show hypogeal germination except rajma. All cereals show hypogeal germination. It varies from 2cm-3cm for different rabi/*kharif* crops.

NUTRIENT MANAGEMENT:

- Nutrients are required for normal functioning of crop plant.
- Nutrient management basically deals with what to apply, how to apply, how much to apply and when to apply.

WEED MANAGEMENT:

- Weeds cause the major havoc to the crops. Yields are highly affected because of them.
- 2 hoeing’s are required as mechanical control and inter culture operations are done at 20 and 40 DAS.
- Herbicides as pre plant incorporation, pre-emergence and post emergence are also applied.

WATER MANAGEMENT:

- Irrigation requirement varies for crops.
- Mainly during sowing our field should be moist an d we need to give irrigations during the critical stages of different plants.

HARVESTING AND YIELD:

- Harvesting is done when crops attain physiological maturity and then yield attributes are calculated.
- Some crops require milling (rice), ginning (cotton), delinting (cotton) *etc.*

FORAGE CROPS

Kharif Fodders

English Name	Common Name	Scientific Name
Non-leguminous		
Pearl millet	Bajra	*Penisetum typhoides*

Maize	Makka	*Zea mays*
Sorghum	Jowar	*Sorghum bicolar*
Teosinte	Mack chari	*Euchlaena mexicana*
Leguminous		
Cowpea	Lobia	*Vigna sinensis*
Cluster bean	Guar	*Cyamopsis tetragonoloba*
Soyabean	Soya	*Glysine max*

Rabi Fodders

Non-leguminous		
Mustard	Sarson	*Brassica compestris*
Mustard (Indian)	Raya	*Brassica juncea*
Chinese cabbage	Chinese cabbage	*Brassica pekinensis*
Turnip	Salgam	*Brassica rapa*
Turnip	Salgam	*Brassica rapa*
Carrot	Gajar	*Daucus carota*
Leguminous		
Egyptian clover	Berseem	*Trifolium alexandrium*
Indian clover	Senji	*Melilotus alba*
Fenugreek	Metha	*Foenum gracecum*

Perennial Fodders

Lucerne	Rizka	*Medicago sativa*
Napier grass	Elephant grass	*Pennisetum purpurium*

Grasses

Napier grass	Elephant grass	*Pennisetum purpurium*
Guinea grass	-	*Panicum maxicum*
Para grass	Buffalo grass	*Panicum purpuraccens*
Sudan grass	-	*Sorghum sudanese vulgare*
Dina grass	Kyasuwa	*Pennisetum pedicellatum*
Anjan grass	Dhaman	*Cenchrus ciliaris*
Doob grass	Hariyali	*Cynodon dactylon*
Setaria grass	Golden timothy	*Setaria sphacelata*
Rhodes grass	-	*Chloris gayana*

Tree

Khejri	Jaanti	*Prosopis cineraria*
Subabool	-	*Leucaena leucocephala*

MORPHOLOGICAL DESCRIPTION OF *KHARIF* SEASON CROPS

Morphology includes root anatomy, leaf anatomy, and stem. Most important of all is inflorescence. Although morphology varies from crop to crop but we can have a brief description about some *kharif* crops.

RICE:

Leaves: They are narrow and are sessile in nature. The rice leaf is similar to wheat leaf but is usually distinguished from it by length of the ligule. In the rice, the ligule is very prominent (>1cm).
Roots: At first embryonic roots develop which later die and lateral roots develop.
Shoot: It mainly consists of culms, leaves and inflorescence (panicle).
Inflorescence: Rice inflorescence is known as panicle which is a group of spikelets borne on the uppermost node of culm. The primary panicle branch is divided into secondary and sometimes into tertiary branches. These bear spikelets (individual spikelets consists of 2 outer glumes.). All the parts found above the spikelets is known as floret. Lemma and palea are known as hull.

MAIZE:

Leaves: Alternate phyllotaxy is found. It is divided into leaf sheath and leaf lamina. Stomata are present on both surfaces of leaf.

Roots: Root system is fibrous and deep. They are of three types:

Seminal roots or temporary roots: arise at the base of first node of stem under the soil surface just above the scutellar node.

Crown/coronal roots: arise from basal portion of stem. They are functional roots.

Brace/buttress roots: arise from 2nd, 3rd and sometimes 4th nodes above the soil surface. They provide anchorage to the plant.

Inflorescence: Monoecious and protandrous condition is found in maize. Male part is known as tassel while female part is known as silk.

GROUNDNUT:

- Groundnut in general has short-statured plant.
- Leaves are alternate, stipulate and quadri-foliate.
- The flowers are bisexual, zygomorphic, complete and sessile.
- Stem consists of the primary, secondary, and tertiary branches which are found in the semi-spreading and spreading types.

COTTON:

- Cultivated cotton is herbaceous plant which attains a height of 60-200cm.
- The plant has tap root with secondary roots that branch laterally from primary roots.
- There are two buds at the base of each cotton leaf petiole (only fruiting branch bears flowers).
- The flower buds which appear as small, pyramidal shaped green structure are called as square.
- The fruit is enlarged ovary that develops into 3-5 loculed capsular boll.
- The number of seeds in each boll may be 24-50.

PIGEON PEA:

- It has central tap root system with numerous laterals and secondary branches.
- Leaves are trifoliate compound; central leaflet longer than lateral ones.
- The inflorescence is an axillary raceme often forming a terminal panicle.
- The fruit of the pigeon pea is pod.