B.Sc. AGRICULTURE LAB MANUAL

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MIDNAPORE CITY COLLEGE

LAB MANUAL
AGS- 601
Rainfed Agriculture & Watershed Management

Table of Contents

Exp. No	Date of Exp.	Date of Submission	Name of Experiment	Page No.	Signature	Remarks
1			Studies on climate classification, studies on rainfall pattern in rainfed areas of the country and pattern of onset and withdrawal of monsoons			
2			Studies on cropping pattern of different dry land areas in the country and demarcation of dry land area on map of India			
3			Interpretation of meteorological data and scheduling of supplemental irrigation on the basis of evapo-transpiration demand of crops			
4			Critical analysis of rainfall and possible drought period in the country, effective rainfall and its calculation			
5			Studies on cultural practices viz; mulching, plant density, depth of sowing, thinning and leaf removal for mitigating moisture stress			
6			Characterization and delineation of model watershed			
7			Field demonstration on soil & moisture conservation measures			
8			Field demonstration on construction of water harvesting structures.			
9			Visit to rainfed research station/watershed			

Experiment No. 1

Studies on Climate Classification, Studies on Rainfall Pattern in Rainfed Areas of the Country and Pattern of onset and Withdrawal of Monsoons

The purpose of climate classification is to set up climatic types and climatic areas in global measure on the Earth as well as in particular geographical areas. There is interconnection between characteristics of the climate with latitude, georelief and the degree of continentality. ***Climatic zones*** lie in the direction along the parallel (zonally) and they are the base for climate classification.

Classification of dry climates:

1.1 Thornthwaite and Mather (1955)

They have taken the Moisture Index (Im) as the criteria for classification of dry climates

$$I_m = \frac{(P-PE)}{PE} \times 100$$

P = Precipitation, PE= Potential Evapo- transpiration

Table 1: Climate classification of Thornthwaite& Mather

I_m Quantity	Climate classification
100 & above	Per humid
20 to 100	Humid
0 to 20	Moist sub humid
-33.3 to 0	Dry sub humid
-66.7 to -33.3	Semi-arid
-100 to -66.7	Arid

Ex: Calculate I_m if P = 20mm & PE = 60mm?

$$I_m = \frac{(P-PE)}{PE} \times 100$$

$$I_m = \frac{(20-60)}{60} \times 100$$

= -66.66

Conclusion: Moisture index is -66.66 mm so it comes under the climatic classification of per semi-arid region.

Examples:

1. **Calculate I_m, if P = 35 mm & PE = 120 mm?**

2. **Calculate I_m, if P = 20 mm & PE = 100 mm?**

1.2 Troll (1965)

- Based on thermal and hygric variables and number of humid months, climate is classified and said to be of agricultural use.
- Humid month is one having mean rainfall exceeding the mean potential evapotranspiration. ICRISAT classified the Semi-arid tropics (SAT areas) in India by adopting this classification.
- According to this classification, a climate which has 5 to 10 arid months(a month where precipitation is less than PET) or 2 to 7 humid months is called semi-arid tract (SAT), whereas humid climate will have 7 to 12 humid months and arid climate has less than 2 humid months.

Table 2: Climate classification of Troll

Humid months	**Climate classification**
12 to 9.5	Tropical rainforest
9.5 7.0	Humid savannah
7.0 4.5	Dry savannah
4.5 2.0	Thorn savannah
2.0 1.0	Semi desert
1.0 0.0	Desert

1.3 Papadakis (1961)

$$H = \frac{(P+W)}{E}$$

Where, P = Monthly precipitation, E = Monthly PET, W = Water stored from previous rainfall

Table 3: Climate classification of Papadakis

H Value	Climate
< 0.25	Arid
0.25 to 0.50	Dry
0.50 to 0.75	Intermediate
0.75 to 1.0	Intermediate humid
1.0 to 2.0	Humid
>2	wet

Moisture Index (H) based on precipitation, soil moisture storage and PET was developed.

Examples: Calculate moisture index (H) If P = 30mm, Evaporation of June = 60mm & water stored in root zone in May month = 5mm.

$$H = \frac{(P+W)}{E}$$

$$H = \frac{(30+5)}{60}$$

= 0.58

Conclusion: Moisture index is 0.58mm so it comes under the climatic classification of intermediate climate.

Examples:

1. **Calculate moisture index (H) If P = 20mm, Evaporation of July = 100mm & water stored in root zone in June = 5mm.**

3. **Calculate moisture index (H) If P = 40mm, Evaporation of October = 100mm & water stored in root zone in September = 15mm.**

1.4 Hargreaves (1971): Moisture Availability Index (MAI) is used for the classification. It is the ratio of dependable precipitation to potential evapotranspiration. It is a measure of adequacy of precipitation in supplying crop water demand.

Table 4: Climate classification of Hargreaves

MAI	Climate Classification
0 to 0.33 during all months	Very arid
>0.34 for 1-2 months	Arid
> 0.34 for 3-4 Consecutive months	Semiarid

Rainfall Pattern:

Rainfall varies both in time and space. Rainfall varies from season to season and year to year. Generally higher the rainfall less is the coefficient of variation. In other words without rainfall crop failures occurs mostly, in the regions of arid and semiarid regions. So rainfall pattern is so important in dryland areas to grow crops according to the season.

1. Amount of rainfall
2. Intensity of rainfall
3. Time of rainfall
4. Duration of rainy season
5. Distribution of rainfall
6. Onset of monsoon
7. Dry spell
8. Wet spells
9. Early withdrawal of monsoon

Amount of rainfall:

It varies from year to year. Generally yield levels are determined by amount of rainfall but, yields are not in direct proportion to amount of rainfall. Crop failure is more common.

Intensity of rainfall:

In most parts of India more than 50% rain is received in 3-5 days. High intensity causes loss of water through runoff. It also causes soil erosion.

Timing:

Rainfall is highly variable in time & space. Starting of rainy season is an important agro climate variable as rainfall is required initially for land preparation and sowing. It is also possible to estimate distribution of the start of the rains commencing on different dates using historical weather data.

Duration of rainy season:

The length of growing season is limited by the duration of rainy season. It depends upon:

1. Starting of rainy season (Late onset)
2. Distribution of rainfall (Dryspell)
3. Ending of rainy season
4. Nature of soil with regard to water holding capacity

Distribution of rainfall:

There is a large variation in commencement of rainy season from year to year. The monsoon is not continuous. Dry spells interspecific with wet spells sometimes to a period of even one month. There is a large year to year variation in the dates of cessation of S.W monsoon. There is a variation in the quantum of rainfall received.

Onset of monsoon:

Long term data on onset of monsoon indicate that onset over Kerala state varies between 30 may to 2 June. It will extend all over India within 8-9 days. Delay in monsoon results in delay in sowing of crop. It also causes shifting of crops from commercial crops to pulse and other less remunerative crops.

Dry spells:

It is the number of continuous rainless days. It is a common feature of SW monsoon. A dry spell of round 10 days for sandy soils. 15 days for sandy loamy soils. 20 days or clay loams is critical. The no. of dry spells if more definitely affect the yield in dry lands.

Early withdrawal of monsoon:

Post rainy season crops fail due to less available soil moisture in the soil. It ultimately leads to poor grain yield. Cycles of periods of low rainfall alternating with periods of higher rainfall as symbolized.

Exercise:

1. **Write in detail about troll's classification?**

2. **Write the rainfall pattern in India?**

3. **What is dry spell?**

4. **Write the limitations for climatic classifications?**

1.5 Conclusion:

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Experiment No. 2

Studies on Cropping Pattern of Different Dry Land Areas in the Country and Demarcation of Dry Land Area on Map of India

Cropping Pattern: Yearly sequence and spatial arrangement of crops on a given area. Means the proportion of area under various crops at a point of time in a unit area. This means the type and arrangement of crops in time and space.

2.1 Aim

- To acquaint with methodology to know about the cropping patterns in the country.
- To demarcate the dry land area on the maps for identification.

2.2 Materials required

1. Graph
2. Pencil
3. Data

The selection of crops and their varieties is to be made depending on the soil and rainfall situation in the rained areas. The photo insensitive crops and varieties with shorter duration should be chosen to escape drought of different intensities. There are wide variations, location to location in water availability periods in dry land areas. Thus depending upon water availability following are the different crops and cropping patterns to suit different climatic situations.

Table 1: Cropping pattern with varying rainfall and soil moisture storage capacity

Rain Fall (mm)	Storage Capacity Of Soil (mm)	Cropping Pattern
350-625	100	Single crop in *kharif*
650-750	100	Intercropping can be attempted
780-900	150	Sequential cropping is possible
900 and above	200	Sequential cropping is assured

Crop selection in Dry lands

Crop selection is very important in dry land areas. The selection should be done based on the following parameters.

Climate: Rainfall, temperature, humidity, sunshine are the main components of climate. However, rainfall is the main item considered for determining the effective cropping/growing season of a dry area. The effective cropping season, often called as Length of growing period (LGP) of dry land area generally depends upon the natural moisture availability in the soil.

Length of Growing period	**Cropping system that can be adapted**
Less than 75 days	Perennial vegetation / mono cropping with short duration pulses
75 to 140 days	Monocropping
140 to 180 days	Inter cropping
More than 180 days	Double cropping

Table 2: Crops suitable for rained areas are:

Monoculture	Scarcity zone	Pearl millet, red gram, green gram, black	
		gram, Horse gram, groundnut	
		Rabi : Jowar Safflower	
	Assured rainfall	Cotton, sorghum, red gram, black gram,	
		green gram, soybean, sunflower	
Double cropping	Scarcity zone	Kharif crops Mung / UridMung / Urid Sunflower Bajra Bajra	Rabi crops Safflower Jowar Gram Gram Safflower
	Assured rainfall zone	Paddy Soybean Mung/Urid Mung/Urid Sunflower	Gram Safflower Jowar Safflower Gram
	Irrigated areas	Jowar Jowar Maize Grunt Grunt	Wheat Gram Wheat Jowar Sunflower

2.3 Grassland or pasture management

Most of the marginal lands are not able to sustain arable crops particularly during the drought years. Such lands can be developed into dependable pastures by following soil and water conservation measures like contour trenches and contour furrows. Controlled grazing may also help in building the forage resource.

In rained areas, different legumes from the genera Dolichos, Leucaena, Clitoria, Cassia and Stylosanthes have been found to do well with or without grasses like Cenchrus ciliaris but Stylosanthes has been found to be excellent in all situations with regard to persistence, nutritive value and palatability.

Different grasses from the genera Dichanthium, Cenchrus, Lasiurus, Chloris, Urochloa, Panicum, and Pennisetum *etc*. have been observed doing well. Cenchrus ciliaris has been found to be good in most of the situations.

The pastures are easily established if they are seeded at the beginning of rainy season. Seeds of *Cenchrus ciliaris* @ 1.0 Kg. Stylo santheshamata @ 4.0 Kg and Stylo santhesscabra @ 1.0 Kg per hectare may be used as seed moistures. The seed moisture may be broadcasted on a drizzling day. After that, light raking of the soil may improve germination chances considerably.

Exercise:

1. **What is cropping system?**

2. **How you select the crops in dryland areas?**

Demarcate the dry land areas in India map:

2.4 Conclusion

Signature of Faculty In-charge

Experiment No. 3

Interpretation of meteorological data and scheduling of supplemental irrigation on the basis of evapo-transpiration demand of crops

The crop water need (ET crop) is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration. In other words, it is the amount of water needed by the various crops to grow optimally. The crop water need always refers to a crop grown under optimal conditions, i.e. a uniform crop, actively growing, completely shading the ground, free of diseases, and favorable soil conditions (including fertility and water). The crop thus reaches its full production potential under the given environment.

The crop water need mainly depends on:

Climate: in a sunny and hot climate crops need more water per day than in a cloudy and cool climate.

Crop type: crops like maize or sugarcane need more water than crops like milletor sorghum

Growth stage of the crop: fully grown crops need more water than crops that have just been planted.

To obtain the highest gain from gradually decreasing irrigation water resources and narrowing agricultural areas, one must obtain the highest yield with per unit water from a unit of area. Therefore, it is important to set up irrigation scheduling for optimum crop yield. Irrigation scheduling is one of the most effective tools to preserve water and it makes possible an increase in crop yield, water economy by better adjustment to the crop requirements during the growth season and energy savings by avoiding excessive water application. Crop evapotranspiration is an important components used in the planning, design, construction, operation and maintenance of irrigation systems. Because crop evapotranspiration largely depends on soil and climatic conditions, it must be determined for each crop in different regions.

This is due to identical effects of air temperature and solar radiation on both crop evapotranspiration and pan evaporation. In other words, climatically factors affecting evaporation also affect crop evapotranspiration and evaporation pans provide a measurement of the combined effect of temperature, humidity, wind speed and sunshine on the crop water consumption. Studies have shown that evaporation pans can be used in the irrigation programs and correlation between pan evaporation and crop evapotranspiration is higher than other empirical relationships. To schedule irrigations using the water budget method, the irrigation system manager must be able to measure or estimate the rate at which water is being used by a crop. Evaporation pans can be used to indicate the rate of crop water use. An evaporation pan is an open pan of water that is subject to the same climatic conditions with a growing crop and from which water is evaporated as a result of the climatic conditions.

3.1 INFLUENCE OF CLIMATE ON CROP WATER NEEDS (ETo)

Introduction

The major climatic factors which influence the crop water needs are:

- Sunshine
- Temperature
- Humidity
- Wind speed

Table 3.1: Effect of Major Climatic Factors on Crop Water Needs

Climatic Factor	Crop water need	
	High	**Low**
Temperature	Hot	cool
Humidity	low (dry)	high (humid)
Windspeed	Windy	little wind
Sunshine	sunny (no clouds)	cloudy (no sun)

The highest crop water needs are thus found in areas which are hot, dry, windy and sunny. The lowest values are found when it is cool, humid and cloudy with little or no wind.

The influence of the climate on crop water needs is given by the **reference crop evapotranspiration** (ETo). The ETo is usually expressed in millimetres per unit of time, e.g. mm/day, mm/month, or mm/season. Grass has been taken as the reference crop.

Definition: ETo is the rate of evapotranspiration from a large area, covered by green grass, 8 to 15 cm tall, which grows actively, completely shades the ground and which is not short of water.

There are several methods to determine the ETo. They are either:

1. Experimental, using an evaporation pan, or
2. Theoretical, using measured climatic data, e.g. the Blaney-Criddle method.

3.2 Methods to determine reference crop evapotranspiration:

3.2.1 Pan Evaporation Method: Evaporation pans provide a measurement of the combined effect of temperature, humidity, windspeed and sunshine on the reference crop evapotranspiration ETo.

Many different types of evaporation pans are being used. The best known pans are the Class A evaporation pan (circular pan) (Fig. 8a) and the Sunken Colorado pan (square pan) (Pig. 8b).

The principle of the evaporation pan is the following:

1. The pan is installed in the field
2. The pan is filled with a known quantity of water (the surface area of the pan is known and the water depth is measured)
3. The water is allowed to evaporate during a certain period of time (usually 24 hours). For example, each morning at 7 o'clock a measurement is taken. The rainfall, if any, is measured simultaneously
4. After 24 hours, the remaining quantity of water (i.e. water depth) is measured
5. The amount of evaporation per time unit (the difference between the two measured water depths) is calculated; this is the pan evaporation: E pan (in mm/24 hours)
6. The E pan is multiplied by a pan coefficient, K pan, to obtain the ETo.
   Formula:

$$\boxed{\textbf{ETo} = \textbf{K pan} \times \textbf{E pan}}$$

ETo: reference crop evapotranspiration
K pan: pan coefficient
E pan: pan evaporation

Determination of K pan

When using the evaporation pan to estimate the ETo, in fact, a comparison is made between the evaporation from the water surface in the pan and the evapotranspiration of the standard grass. Of course the water in the pan and the grass do not react in exactly the same way to the climate. Therefore a special coefficient is used (K pan) to relate one to the other.

The pan coefficient, K pan, depends on: The type of pan used, pan environment: if the pan is placed in a fallow or cropped area and the climate: the humidity and wind speed.

For the Class A evaporation pan, the K pan varies between 0.35 and 0.85. Average K pan = 0.70.

For the Sunken Colorado pan, the K pan varies between 0.45 and 1.10. Average K pan = 0.80.

Excercise:

1) Type of pan: Class A evaporation pan
Water depth in pan on day 1 = 150 mm
Water depth in pan on day 2 = 144 mm
Rainfall (during 24 hours) = 0 mm
K pan = 0.75, Now calculate ET_o with the given data?

2) Type of pan: Sunken Colorado pan
Water depth in pan on day 1 = 411 mm
Water depth in pan on day 2 = 409 mm (after 24 hours)
Rainfall (during 24 hours) = 7 mm
K pan = 0.90, calculate E pan and ET_0 with the given data?

3) Type of pan: Sunken Colorado pan
Water depth in pan on day 1 = 380 mm
Water depth in pan on day 2 = 205 mm (after 24 hours)
Rainfall (during 24 hours) = 3 mm
K pan = 0.52, calculate E pan and ET_0 with the given data?

3. **Draw the image of open pan evaporimeter?**

3.3 Conclusion

Experiment No. 4

Critical analysis of rainfall and possible drought period in the country, effective rainfall and its calculation

There are several methods of assessing effective rainfall. Each method has certain merits and limitations. Some of the methods like

1. Soil Moisture Changes
2. Ramdas Method
3. Lysimeters
4. Empirical methods

Important methods are discussed below for the easy under stance and easy remembrance.

4.1 Soil Moisture Changes

Water in the root zone may be measured by sampling and oven-drying the soil before and after every shower of rain. The increase in soil moisture, plus evapotranspiration loss (ETa) from the time the rain starts until the soil is sampled, is the amount of effective rainfall. After heavy rainfall evapotranspiration can be assumed to be at the potential rate during the short period from cessation of rainfall until the sampling time. This can be taken as 0.4 to 0.8 times the evaporation value of the Class A Pan as is given in FAO Irrigation and Drainage paper No. 24 (1974), or

$ER = M_2 - M_1 + kpEo$
ER = effective rainfall
Eo = U.S. Class A Open Pan evaporation value or M_1 and
M_2 = moisture status in the effective root zone before and after rain, respectively
kp = pan coefficient

The method takes into account the soil and the crop characteristics. The determination is simple and accurate but it may involve errors due to soil variation; the sampling errors may range from 5 to 40 percent. The method is also laborious and time consuming. The use of neutron probes reduces the drudgery of periodic soil sampling, but these are costly methods for routine purposes and also subject to sampling errors.

4.2 Ramdas Method

Ramdas (1960) suggested a direct field method using a small portable device containing soil of the field, so eliminating the necessity of sampling.

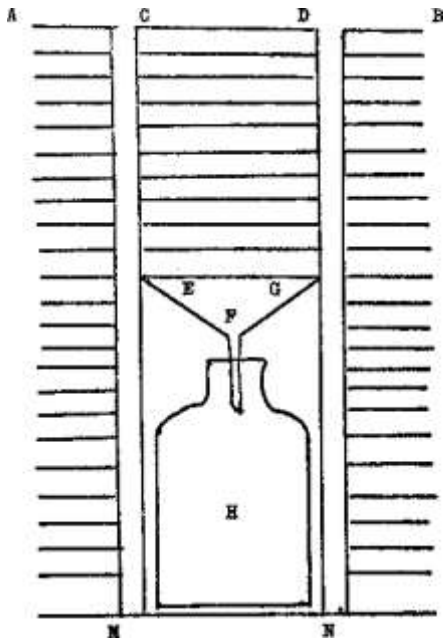


Fig 1: Ramdas Apparatus for Measuring Effective Rainfall

The apparatus as shown, consists of a cylinder (CD) of about 30 cm in diameter, with a perforated base (BO) and a funnel (F) leading into a receiver bottle (H). All these parts are enclosed in an outer cylinder (MN). The cylinder (CD) is filled with a representative soil with the same density as that of the field. The height is equal to the depth of the effective root zone of the crop.

The apparatus is installed in the field crop where the effective rainfall is to be measured. The crop in the container is irrigated along with the field crop. Excess rain or irrigation water drains in the receiver bottle H and is measured from time to time. The total rainfall minus the ineffective rainfall gives the value of effective rainfall. It is assumed that there is no surface run-off. Cylinders of different lengths are used consistent with the rooting depth of the different crops. With a suitable number of replications, the method is very useful. It is simple and practical and furnishes direct readings.

4.3 Lysimeters

Lysimeter is a method which provides complete information on all the components of water balance. Lysimeters can be used not only for measuring evapotranspiration but also for checking empirical formulae for computing ET. The method is similar to the Ramdas method, but is more elaborate, refined and gives a higher accuracy.

A lysimeter is a large container with soil in which crops are grown; water losses and gains can be measured. The container is fitted with suitable inlets for irrigation and outlets for drainage. The lysimeters are buried in the field and are surrounded by the same crop as is grown inside. The size of lysimeter varies from small oil drums. They can be either the non-weighing or weighing type.

Limitations

1. Lysimeters are the restricted root growth, the disturbed soil structure in the lysimeter causing changes in water movement and possibly the tank temperature regime, resulting in condensation of water on the walls of the container.
2. Other limitations include the 'bouquet effect' whereby the canopy of the plants grown in the lysimeter is above and extends over the surrounding crop, resulting in a higher evapotranspiration rate.
3. In spite of these limitations, it is the best technique for precise studies on evapotranspiration.

4.4 Empirical Methods

In cases where all the water needed for optimal growth of the crop is provided by rainfall, irrigation is not required and the Irrigation water need (IN) equals zero: IN = 0.

In cases where there is no rainfall at all during the growing season, all water has to be supplied by irrigation. Consequently, the irrigation water need (IN) equals the crop water need (ET crop): IN = ET crop.

In most cases, however, part of the crop water need is supplied by rainfall and the remaining part by irrigation. In such cases the irrigation water need (IN) is the difference between the crop water need (ET crop) and that part of the rainfall which is effectively used by the plants (Pe). In formula: IN = ET crop - Pe.

In summary

If sufficient rainfall	: IN = 0
If no rainfall at all	: IN = ET crop
If partly irrigation, partly rainfall	: IN = ET crop - Pe

Determination of the Effective Rainfall

The amount, the intensity and the distribution of rainfall is important.

1. When rain water falls on the soil surface, some of it infiltrates into the soil, some stagnates on the surface, while some flows over the surface as runoff.
2. When the rainfall stops, some of the water stagnating on the surface evaporates to the atmosphere, while the rest slowly infiltrates into the soil.
3. From all the water that infiltrates into the soil, some percolates below the root zone, while the rest remains stored in the root zone.

In other words, the effective rainfall is the total rainfall minus runoff minus evaporation and minus deep percolation.

EF = Total rainfall – Runoff – Evaporation – Deep percolation

Only the water retained in the root zone can be used by the plants, and represents what is called the effective part of the rainwater.

The term effective rainfall is used to define this fraction of the total amount of rainwater useful for meeting the water need of the crops.

Only 2 simple formulae are provided to estimate the fraction of the total rainfall which is used effectively. These formulae can be applied in areas with a maximum slope of 4-5%:

$Pe = 0.8\ P$ if $P > 75$ mm/month
$Pe = 0.6\ P$ if $P < 75$ mm/month
with P = rainfall or precipitation (mm/month)
Pe = effective rainfall or effective precipitation (mm/month)

NOTE: Pe is always equal to or larger than zero; never negative

Excercise

1. **Calculate the effective rainfall for the following monthly rainfall figures: P = 35, 90,116, 5, 260, 75 mm**

2. **Calculate the effective rainfall for the following months both in mm/month and in mm/day.**

Month	Feb	Mar	Apr	May	June
ET crop (mm/month)	69	123	180	234	180
P (mm/month)	20	38	40	80	16

3. **Calculate the irrigation water need, both in mm/month and mm/day, using the formula: IN = ET crop – Pe**
   Ex: Feb: IN = 60 - 5 = 50 mm

	February	March	April	May	June
ET_o	60	100	160	220	160
P_e	5	10	10	30	0

4. **Calculate the irrigation water need, both in mm/month and mm/day, using the formula: IN = ET crop – Pe**
   Ex: Feb: IN = 60 - 5 = 50 mm

	February	March	April	May	June
ET_o	40	80	160	200	140
P_e	5	10	10	30	0

4.5 Conclusion

Experiment No. 5

Studies on Cultural Practices viz; Mulching, Plant Density, Thinning and Leaf Removal for Mitigating Moisture Stress

Improving soil moisture conservation is an ongoing goal in agricultural production, especially in India, where water resources are limited and regulated. One reason that there is a push to use less water in agriculture is because of increasing demand generated by the increasing population in India. The water demands of urban populations are essentially fixed and increase, so water availability for agricultural producers is constantly reduced. To address both of these issues, farmers are searching for new ways to improve soil moisture in drylands.

5.1 Aim

To know about different methods for reducing moisture stress.

5.2 Materials Required

1. Note book
2. Pen/ pencil
3. Any mulching materials like: straw, pebbles, husk etc.

5.3 Different methods for mitigating stress are

1. Mulching
2. Thinning
3. Depth of sowing
4. Leaf removal
5. Plant density

5.3.1 Mulching

It is one cultural practice which can be used to addresses this problem. Covering the ground with mulch saves water by preventing surface evaporation. The layer can also greatly reduce or eliminate weed propagation, which will also result in higher water use efficiency. Using certain agricultural byproducts as mulch is a sustainable practice which can reduce water use and provide other benefits as well. Wheat straw, grass clippings, and leaf debris are fairly abundant byproducts.

Mulching, the word mulch has probably been derived from the German word "molsch" meaning soft to decay, which apparently referred to the gardener's use of straw and leaves as a spread over the ground as mulch. It consists of covering the soil surface with organic material and inorganic materials, is an age old practice and was used to control soil moisture, soil temperature, nutrient loss, salinity, erosion soil structure etc. However, with modern agriculture, this practice dwindled largely, but is now gaining importance once again in the context of sustainable agriculture. Various types of mulches have been demonstrated to reduce soil erosion by more than 90% compared to bare agricultural soil.

5.3.2 Plant Density

Plant density is very much important for getting good yields if irrigation is available properly. In drylands the irrigation is the most limiting factor so that yields are decreasing drastically in those areas. To get yields plant population should be lesser in dryland conditions than under irrigated conditions. The rectangular type of planting pattern should always be followed under dryland conditions. Under dryland conditions whenever moisture stress occurs due to prolonged dry spells, under limited moisture supply the adjustment of plant population can be done by

- Increasing the inter row distance: By adjusting more number of plants within the row and increasing the distance between the rows reduces the competition during any part of the growing period of the crop. Hence it is more suitable for limited moisture supply conditions.
- Increasing the intra row distance: Here the distance between plants is increased by which plants grow luxuriantly from the beginning. There will be competition for moisture during the reproductive period of the crop. Hence it is less advantageous as compared to above under limited moisture supply.

5.3.3 Thinning

Thinning is done to maintain optimum plant population so that the competition (for different sources like light, moisture, nutrients, CO_2) will be less in between the plants. This can be done by removing every alternate row or every third row which will save the crop from failure by reducing the competition if the crop is closely planted.

5.3.4 Leaf Removal

Normally the plants growing in irrigated conditions will grow vigoursly because of the presence of sufficient amount of water and nutrients in the soil. So in these plants transpiration rate will be less compared to moisture stress conditions. Whereas, the plants growing in dryland areas shows wilting symptoms because of lack of moisture in the soil. So to reduce the wilting symptoms we can remove the leaves (No. of leaves will be reduced. Mostly the older 2 to 3 leaves will be removed) of the plant so that, the transpiration rate will be reduced and conserves the water. The removed leaves can be used as a mulching.

5.3.5 Depth of sowing

It also helps in mitigating moisture stress to plants. If plants are shallow planted due to lack of moisture the seed germination may be stopped. If seeds are sown very deep into the soil, seed maynot be germinated and shows dormancy. So optimum seed depth should be maintained around 3-4 cm depth based on diameter of the crop.

Exercise

1. **Write the different mulching materials used to conserve moisture?**

2. **Thinning should be done at how many days after sowing for crops?**

3. **Reason for removal of older leaves?**

4. **Increase of intra row/ inter row spacing increases plant survival, Justify the question?**

5.4 Conclusion

Experiment No. 6

Characterization and Delineation of Model Watershed

Imagine a watershed as an enormous bowl. As waterfalls onto the bowl's rim, it either flows down the inside of the bowl or down the outside of the bowl. The rim of the bowl or the watershed boundary is sometimes referred to as the ridgeline or watershed divide. This ridge line separates one watershed from another.

Topographic maps created can help you to determine a watershed's boundaries. Topographic maps have a scale of 1:24,000 (which means that one inch measured on the map represents 24,000 inches [2000'] on the ground). They also have contour lines that are usually shown in increments of ten or twenty feet. Contour lines represent lines of equal elevation, which typically is expressed in terms of feet above mean sea level. As you imagine water flowing downhill, imagine it crossing the contour lines perpendicularly.

6.1 Steps to Determine Watershed:STEP 1

Use a topographic map(s) to locate the river, lake, stream, wetland, or other water bodies of interest. (See the example, West Branch of Big River, in Figure -1.)

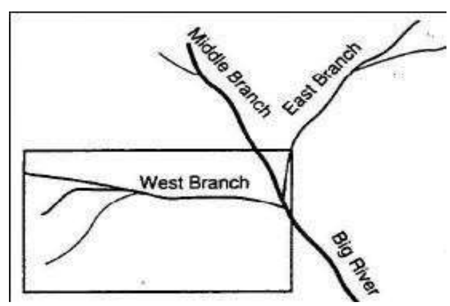


Fig 1: Map indicating rivers border

STEP 2

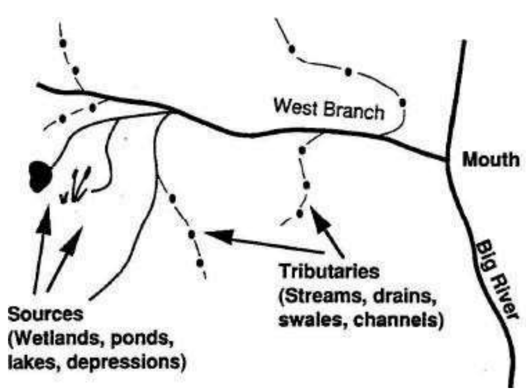


Fig 2: Map indicating rivers boundaries

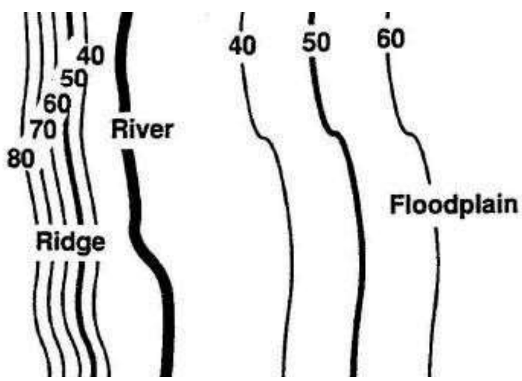
Trace the watercourse from its source to its mouth, including the tributaries (Figure-2). This step determines the general beginning and ending boundaries.

STEP 3

Examine the brown lines on the topographic map that are near the watercourse. These are referred to as contour lines. Contour lines connect all points of equal elevation above or below a known reference elevation.The dark contour lines (thick lines) will have a number associated with them, indicating the elevation.

The light contour lines (thin lines) are usually mapped at 10 (or 20) foot intervals, and the dark brown (thick) lines are usually mapped at 50 (or 100) foot intervals. Be sure to check the map's legend for information on these intervals. To determine the final elevation of your location, simply add or subtract the appropriate contour interval for every light brown (thin) line, or the appropriate interval for every dark (thick) line.

STEP 4



Contour lines spaced far apart indicate that the landscape is more level and gently sloping (i.e., they are flat areas). Contour lines spaced very close together indicate dramatic changes (rise or fall) in elevation over a short distance (i.e., they are steep areas)

Fig 3: Map indicating Contour lines

STEP 5: Check the slope of the landscape by locating two adjacent contour lines and determine their respective elevations. The slope is calculated as the change in elevation, along a straight line, divided by the distance between the endpoints of that line. A depressed area (valley, ravine, swale) is represented by a series of contour lines "pointing" towards the highest elevation (Figure - 4). A higher area (ridge, hill) is represented by a series of contour lines "pointing" towards the lowest elevation.

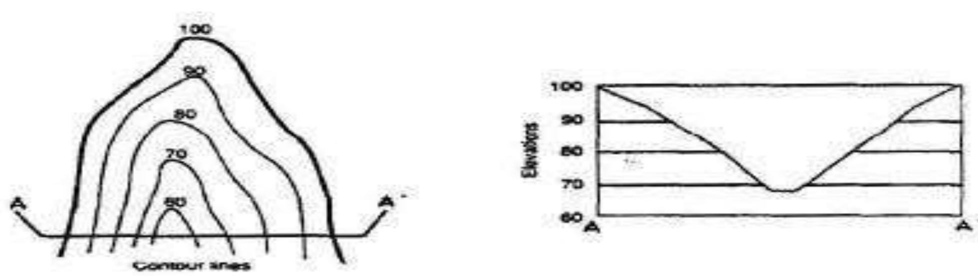


Fig 4: Map pointing out Contour lines towards higher

STEP 6

Determine the direction of drainage in the area of the waterbody by drawing arrows perpendicular to a series of contour lines that decrease in elevation. Stormwater runoff seeks the path of least resistance as it travels downslope. The "path" is the shortest distance between contours, hence a perpendicular route (Figure - 5). Mark the break points surrounding the waterbody. The "break points" are the highest elevations where half of the runoff would drain towards one body of water, and the other half would drain towards another body of

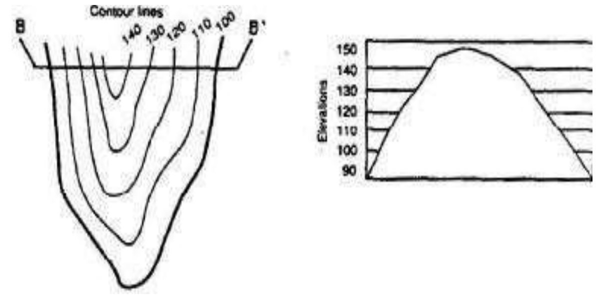


Fig 5: Image indicating the breakpoints

STEP 7

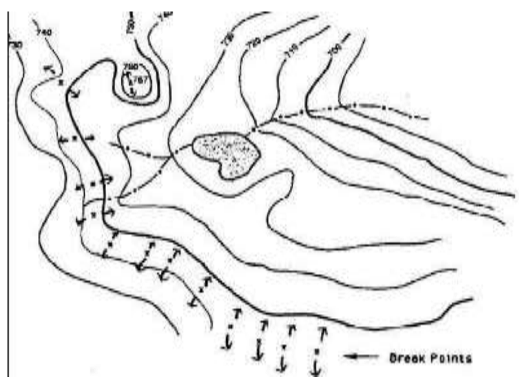


Fig 6: Connecting points with a lines

IDENTIFY BREAK POINTS: Connect the break points with a line following the highest elevations in the area. The completed line represents the boundary of the watershed (Figures - 6).

STEP 8

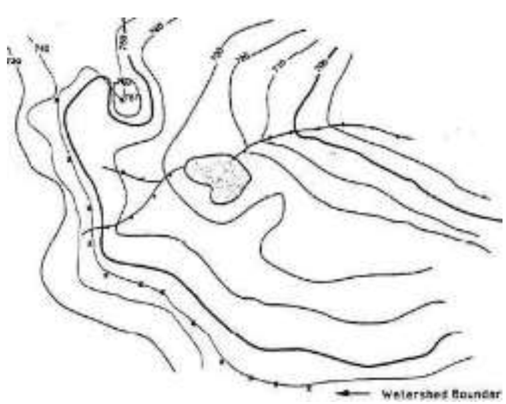


Fig 7: Imaginary boundary of watershed

Once you've outlined the watershed boundaries on your map, imagine a drop of rain falling on the surface of the map. Imagine the water flowing down the slopes as it crosses contour lines at right angles. Follow its path to the nearest stream that flows to the water body you are studying. Imagine this water drop starting at different points on the watershed boundaries to verify that the boundaries are correct.

STEP 9

Watersheds sometimes have what are termed subwatersheds within them. Rivers, large streams, lake, and wetland watershed often have more than one subwatershed (usually smaller tributary watersheds) within them. Generally, the larger the waterbody you are examining, the more subwatersheds you will find. Your watershed map can be further divided into smaller sections or subwatersheds if it helps organize your study better.

STEP 10

Once the watershed and subwatershed (optional) boundaries have been delineated on the map, we can verify them in the field, if necessary

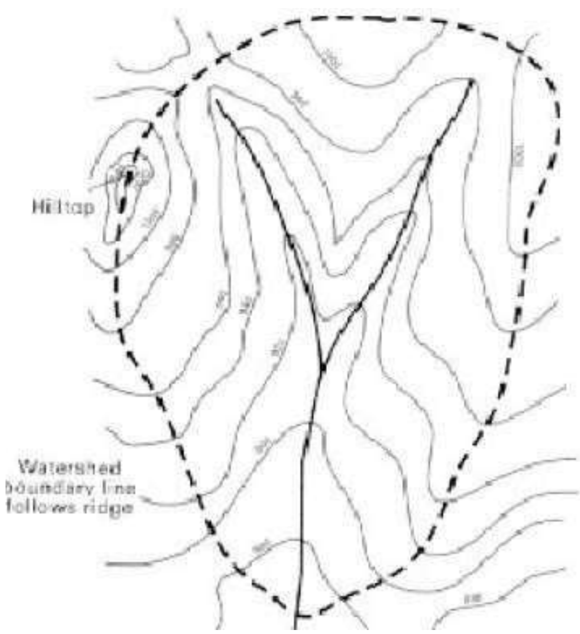


Fig 8: Complete Watershed Image

6.2 Watershed Characterization

It is a set of water and habitat assessments that compare areas within a watershed for restoration and protection value.

It is a coarse-scale tool that supports decisions regarding:

1. Where on the landscape should efforts be focused first?

2. What types of actions are most appropriate to that place?

It provides an initial filter for regional and local governments in landscape-level planning.

Results can identify areas of the landscape that are:

1. Priorities for acquisition (or protection via conservation easements)
2. More appropriate for restoration (mitigation/conservation banks)
3. Less likely to be damaged from development impacts.

This helps direct limited funds to areas with greater probability of successful protection and restoration of aquatic and terrestrial resources, while providing a predictable land use framework. Such a framework guides continuous land and water quality improvement leading to sustainable development within watersheds.

6.3 Purposes of Watershed Characterization in Land Use Planning

1. To sustain and restore aquatic resources.

2. To establish a common approach to coordinate planning efforts.

3. To involve the community in developing a green infrastructure plan.

4. To promote the integration of the Growth Management Act (GMA) and Shoreline Management Act (SMA).

Exercise

1. **Imagine a watershed of different dimensions and create the watershed?**

2. **What is watershed characterization?**

3. **Write the purposes of watershed characterization?**

6.4 Conclusion

Experiment No. 7

Field Demonstration on Soil & Moisture Conservation Measures

7.1 Aim

To study the different soil and water conservation techniques
To know how crops are grown even in difficult situations

7.2 Materials required

1. Hand hoe
2. Spades
3. Measuring tape
4. Observation book
5. Pen/pencil

Fertile soil and good quality water have become precious natural resources, their efficient and economical use is the first and foremost action to conserve them. The practical methods for soil and water conservation can be broadly divided into two classes.

Table 1: Different Soil and Water Conservation Measures

Agronomical Measures (Biological)	Engineering Practices
1. **Contour cultivation**	1. Terracing a. Diversion terrace: i. Magnum type. ii. Nicholas type. iii. Broad based type iv. Narrow based type b. Retention Terrace c. Bench terrace
2. Strip Cropping 1. Contour strip cropping 2. Field strip cropping 3. Buffer strip cropping 4. Wind strip cropping	2. Bunding a. Contour bunding 1. Narrow based 2. Broad based b. Side bunds c. Lateral bund d. Supplemental bunds e. Marginal bund f. Shoulder bund

3. Tillage practices a. Mulch Tillage b. Vertical mulching c. Minimum tillage d. Conventional tillage e. Listening	
4. Soil management practices	
5. Supporting Practices (Interplanting, fertilizer application)	
6. Vetiver grass planting	

By following different practices we can reduce soil erosion, increase moisture holding capacity of soil and can minimize problems like water logging, soil salinization etc.

Exercise

1. **Write about bench terracing?**

2. **Write the mulching and its types?**

3. **What is contour bunding?**

4. **What is contour strip cropping?**

5. **What slope should be there in soil to follow mechanical measures?**

Draw the images for different moisture conservation measures:

Contour planting **Strip cropping**

Vertical mulching **Contour bunding**

Terracing

7.3 Conclusion

Experiment No. 8

Field Demonstration on Construction of Water Harvesting Structures

8.1 Aim

To study about the water storage structures
To get acquaint with different methods of water storage in different areas

8.2 Materials required

1. Spades
2. Hand hoes
3. Crowbar
4. Observation book
5. Pencil

The process of collection of runoff water during the peak periods of rainfall into storage tanks, ponds etc., is known **as water harvesting.** Water harvesting is done both in arid and semi-arid regions with certain differences. In arid regions, the collecting area or catchment area is substantially in higher proportion compared to command area.

8.3 Following are the several water harvesting structures

1. Wells
2. Percolation tanks
3. Farm ponds
4. Check dams/cement plug
5. Tanka/ Kundi
6. Underground bandharas/ Ground water dams

8.3.1 Wells: Hand dug wells have been used to collect and store underground water and this water is lifted for irrigation. The quality of water is generally poor due to dissolved salts.

8.3.2 Tanks: Runoff water from hill sides and forests is collected on the plains in tanks. The traditional tank system has following components viz., catchment area, storage tank, tank bund, sluice, spill way and command area. The runoff water from catchment area is collected and stored in storage tank on the plains with the help of a bund.

8.3.3 Percolation Tanks: Flowing rivulets or big gullies are obstructed and water is ponded. Water from the ponds percolates into the soil and raises the water table of the region. The improved water level in the wells lower down the percolation tanks are used for supplemental irrigation.

8.3.4 Farm Ponds: These are small storage structures for collection and storage of runoff water.

8.3.5 Tanka/ Kundi: Tanka is generally circular in shape and is constructed in stone masonry in 1:3 cement-sand mortar. While small Tankas of 3 to 4.22 m diameter and about 21-59 cum capacity are built by individual households, larger ones of 6 m diameter and 200 cm capacity are built for the village communities.

8.3.6 Check dams: These are constructed across small streams having gentle slope and are feasible both in hard rock as well as alluvial formations. The site selected for check dam should have sufficient thickness of permeable bed or weathered formation to facilitate recharge of stored water within short span of time. The water stored in these structures is mostly confined to stream course and the height is normally less than 2 m. These are designed based on stream width and excess water is allowed to flow over the wall. In order to avoid scouring from excess run off, water cushions are provided at downstream side.

Exercise

1. **What is water harvesting?**

2. **Write the different lining materials used in constructing of checkdams?**

3. **Draw the water harvesting structures?**

8.4 Conclusion

Experiment No. 9

Visit to rainfed research station/watershed

9.1 Aim

To know about the watershed.

9.2 Materials required

1. Observation book
2. Pen/ Pencil

A Watershed also called a drainage basin or catchment area, is defined as an area in which all water flowing into it and goes to a common point. People and livestock are integral part of watershed and their activities affect the productivity status of watershed and vice-versa.

Watershed is not simply the Hydrological Unit but also social, political, ecological entity which plays crucial role in determining food, social and economical security and also provides life-support services to rural people.

Place visited-

Catchment area of watershed-

Storage capacity-

Command area-

Lining materials used-

Description of watershed-

Uses-

9.3 Conclusion

Practical Manual

AGS-602

Protected Cultivation and Secondary AgricultureCredits: 2(1+1)

Semester: VI

Sr. No.	Experiments	Page No.
1	Study of different type of greenhouses based on shape.	
2	Determine the rate of air exchange in an active summer winter cooling system.	
3	Determination of drying rate of agricultural products inside green house.	
4	Study of greenhouse equipments.	
5	Visit to various Post Harvest Laboratories.	
6	Determination of Moisture content of various grains by oven drying & infrared moisture methods.	
7	Determination of engineering properties (shape and size, bulk density and porosity of biomaterials).	
8	Determination of Moisture content of various grains by moisture meter.	
9	Field visit to seed processing plant	

Experiment 1: Study of different type of green houses based on shape.

Green House:

A greenhouse is a framed or an inflated structure covered with a transparent or translucent material in which crops could be grown under the conditions of at least partially controlled environment and which is large enough to permit persons to work within it to carry out cultural operations.

Greenhouse type based on shape

Greenhouses can be classified based on their shape or style. For the purpose of classification, the uniqueness of the cross section of the greenhouses can be considered as a factor. As the longitudinal section tend to be approximately the same for all types, the longitudinal section of the greenhouse cannot be used for classification. The cross sections depict the width and heightof the structure and the length is perpendicular to the plane of cross section. Also, the cross section provides information on the overall shape of the structural members, such as truss or hoop, which will be repeated on every day. The commonly followed types of greenhouse based on shape are lean-to, even span, uneven span, ridge and furrow, saw tooth and quonset.

1 Lean-to type greenhouse

A lean-to design is used when a greenhouse is placed against the side of an existing building. It is built against a building, using the existing structure for one or more of its sides. It is usually attached to a house, but may be attached to other buildings. The roof of the building is extended with appropriate greenhouse covering material and the area is properly enclosed. It is typically facing south side. The lean-to type greenhouse is limited to single or double-row plant benches with a total width of 7 to 12 feet. It can be as long as the building it is attached to. It should face the best direction for adequate sun exposure. The advantage of the lean-to type greenhouse is that, it usually is close to available electricity, water, and heat. It is a least expensive structure. This design makes the best use of sunlight and minimizes the requirement of roof supports. It has the following disadvantages: limited space, limited light, limited ventilation and temperature control. The height of the supporting wall limits the potential size of the design. Temperature control is more difficult because the wall that the greenhouse is built on, may collect the sun's heat while the translucent cover of the greenhouse may lose heat rapidly. It is a half greenhouse, split along the peak of the roof.

2 Even span type greenhouse

The even-span is the standard type and full-size structure, the two roof slopes are of equal pitch and width. This design is used for the greenhouse of small size, and it is constructed on level ground. It is attached to a house at one gable end. It can accommodate 2 or 3 rows of plant benches. The cost of an even-span greenhouse is more than the cost of a lean-to type, but it has greater flexibility in design and provides for more plants. Because of its size and greater amount of exposed glass area, the even-span will cost more to heat. The design has a better shape than a lean-to type for air circulation to maintain uniform temperatures during the winter heatingseason. A separate heating system is necessary unless the structure is very close to a heated building. It will house 2 side benches, 2 walks, and a wide center bench. Several single and multiple span types are available for use in various regions of India. For single span type the span in general, varies from 5 to 9 m, whereas the length is around 24 m. The height varies from 2.5 to 4.3 m.

3 Uneven span type greenhouse

This type of greenhouse is constructed on hilly terrain. The roofs are of unequal width; make the structure adaptable to the side slopes of hill (Fig. 2). This type of greenhouses is seldom used now-a-days as it is not adaptable for automation.

4 Ridge and furrow type greenhouse

Designs of this type use two or more A-frame greenhouses connected to one another along the length of the eave (Fig. 2). The eave serves as furrow or gutter to carry rain and melted snow away. The side wall is eliminatedbetween the greenhouses, which results in a structure with asingle large interior, Consolidation of interior space reduces labour, lowers the cost of automation, improves personal management and reduces fuel consumption as there is less exposed wall area through which heat escapes. The snow loads must be taken into the frame specifications of these greenhouses since the snow cannot slide off the roofs as in case of individual free standing greenhouses, but melts away. In spite of snow loads, ridge and furrow greenhouses are effectively used in northern countries of Europe and in Canada and are well suited to the Indian conditions.

5 Saw tooth type Greenhouse

These are also similar to ridge and furrow type greenhouses except that, there is provision for natural ventilation in this type. Specific natural ventilation flow path develops in a saw- tooth type greenhouse.

6 Quonset greenhouse

This is a greenhouse, where the pipe arches or trusses are supported by pipe purling running along the length of the greenhouse. In general, the covering material used for this type of greenhouses is polyethylene. Such greenhouses are typically less expensive than the gutter connected greenhouses and are useful when a small isolated cultural area is required. These houses are connected either in free, standing style or arranged in an interlocking ridge and furrow. In the interlocking type, truss members overlap sufficiently to allow a bed of plants to grow between the overlapping portions of adjacent houses. A single large cultural space thus exists for a set of houses in this type, an arrangement that is better adapted to the automation and movement of labour.

Experiment 2. Determine the rate of air exchange in an active summer winter cooling system.

Air flow calculation

The airflow leaving an inflated tube through a smooth circular opening can be calculated according to the equation: Airflow (cfm) = Constant * Coefficient of Discharge * Area in Square Feet * the square root of the static pressure within the tube in inches of water.

$Q = 4005X\ CX\ AX\ P^{1/2}$

Q = Airflow in cfm for circular openings (0.60)

C = Coefficient of discharge for circular openings (0.60)

A = Area of opening in square feet (for a circle: $\pi d2/4$)

P = Static pressure in inches of water

4005: Constant for air at standard temperature and pressure

Air Exchange Capacity of a Ventilation System

One way to calculate the air volume being moved by a ventilation system is to measure air speed and cross sectional area through which air is moving.

Air speed (feet per minute, fpm) x Area (sq. ft.) = ventilation rate (cubic feet per minute, cfm)

The air speed moving through the fan and/or inlets should be measured. To determine cross-sectional area, the fan airflow opening should be measured, which is usually the fan diameter, or sum the total inlet are

Experiment 3. Determination of drying rate of agricultural products inside green house.

Drying process can be divided in to three periods:

(i) Constant drying rate period and
(ii) (ii) First falling drying rate period and
(iii) (iii) Second falling rate period.

(i) Constant drying rate period

In a constant drying rate period, a material or mass of material contain so much water that liquid surface exists will dry in a manner comparable to an open faced body of water. Diffusion of moisture from within the droplet maintains saturated surface conditions and as long as these lasts, evaporation takes place at constant rate. When a solid is dried under constant drying conditions, the moisture content $\times_t$ typically falls The graph is linear at first, then curves and eventually levels off. Constant rate drying period will proceed until free moisture appears from the surface, the moisture removal ratewill then become progressively less. The moisture content at which the drying rate ceases to be constant is known as the critical moisture content. During the constant rate period, the moisture from interior migrates to the surface by various means and is vapourised. As the moisture content is lowered, the rate of migration to the surface is lowered. If drying occurs at too high temperatures, the

surface forms the layer of closely packed shrunken cells which are sealed together. This presents a barrier to moisture migration and tends to keep the moisture sealed within. This condition is known as ‘case hardening’.

The constant rate period is characterized by a rate of drying independent of moisture content. During this period, the solid is so wet that a continuous film of water e×ists over the entire drying surface, and this water acts as if solids were not there. The temperature of the wetted surface attained the wet bulb temperature.

Web bulb Temperature (WBT)

WBT is the steady state temp shown by the thermometer whose bulb is covered with a wet wick and from which water is evaporating into a high velocity air stream. The quantity of water evaporated is not high enough to alter the temperature and humidity of the air stream.

The air blown at high velocity (minimum recommended is 300 m/min). It causes evaporation of water from the wick. Evaporation requires latent heat. This heat comes from surface of glass bulb of thermometer. So the temperature of the glass bulb decreases. The the heat comes from the temperature difference between Tw and Ta (large). It is the case of simultaneous heat and mass transfer. This heat is latent heat for phase change of water to water vapor.

q = amount of latent heat transfer

$q = M_w N_w \lambda_w A$ -----------------(i)

M_w = mol. Mass of water kg/kg mol

N_w = molar flu× of water vapour, kg mol m^{-2} s^{-1}

λ_w = Latest heat of vaporization kJ/kg

$N_w = k_y (y_w - y)$

k_y = mass transfer coefficient kg mol m^{-2} s^{-1}

y_w = mole fraction of water vapour in the stagnant air layer adjacent to the wet cloth

y = mole fraction of water vapour in the air stream, some distance away from the wet cloth

$(y_w - y)$ is the driving force.

Where,

w = kg of moistureØ

= time

h = heat transfer coefficient between air and moisture kcal/ kg hr °Cta

= dry bulb temperature of air, °C

ts = surface temperature, °C

A= area, m^2

ΔHv = heat of vapourisation at ts ,Kcal/ kgka

= mass transfer coefficient (kg/ hr m)

Hs = humidity of saturated air at the surface temperature

The constant rate period ends when the migration rate of water from the interior of the surface becomes less than the rate of evaporation from the surface. The period subsequent to the critical point is called 'the falling rate period'. Beyond this point, the surface temperature rises, and the drying rate falls off rapidly. The falling rate period takes a far longer time than the constant rate period, even though the moisture removal may be much less. The drying rate approaches zero at some equilibrium moisture content.

Drying in falling rate period involves two processes:

a) movement of moisture within the material to the surface

b) removal of the moisture from the surface

The method used to estimate drying rates and drying times in the falling rate period depends on whether the solid is porous or non porous. In a non porous material, once there is no superficial moisture, further drying can occur only at a rate governed by diffusion of internal moisture to the surface. In a porous material other mechanism appears, and drying may even takes place inside the solid instead of at the surface.

(ii) First falling drying rate period

Point B, the moisture content at the end of the constant rate period, is the 'critical moisture content'. At this point the surface of the solid is no longer saturated, and the rate of drying decreases with the decrease in moisture content. At point C, the surface moisture film has evaporated fully, and with the further decrease in moisture content, the drying rate is controlled by the rate of moisture movement through the solid.

(iii) Second falling drying rate period

Period C to D represents conditions when the drying rate is largely independent of conditions outside the solid. The moisture transfer may be by any combination of liquid diffusion, capillary movement, and vapour diffusion.

11.2 Estimation of Drying Time

In order to determine the time required to achieve the desired reduction in product moisture content, the rate of moisture removal or drying rate must be predicted. The rate of drying depends on properties of drying air (the dry bulb temperature, RH, and velocity of air and the surface heat transfer coefficient), the properties of food (moisture content, surface to volume ratio and the surface temperature) and rate of moisture loss. The size of the pieces has an important effect on the drying rate in both the constant and falling rate periods. In the constant rate period, smaller pieces have a larger surface area available for evaporation where as in falling rate period smaller pieces have a shorter distance for moisture to travel through the food. Other factors which influence the rate of drying include:

1. The fat content of the food (higher fat contents generally results in slower drying, as water is trapped with in the food).

2. The method of preparation of food (cut pieces lose moisture more quickly than losses through skin.

3. The amount of food placed in a dryer in relation to its size (in a given dryer faster drying is achieved with smaller quantities of food).

For constant rate drying period the following general expression would apply:

$R_c = dw / dt = w_o – w_c / t_c$ -------------- (1)

Where,

w_c = Critical moisture content (kg water / kg dry solid) and

t_c = Time for constant rate drying

During falling rate drying, the following analysis would apply.

$- dw/dt = R_c / w_c (w)$ or

$w_c / R_c ò - dw /w = ò dt$

Where the limits of integration are between critical moisture content w_c or end of constant rate drying, t_c and some desired final moisture content, w.

On integration:

$t – t_c = w_c/R_c \ln(w_c/w)$ or time for falling rate becomes

$t_f = w_c/R_c \times \ln (w_c/w)$------------ (3) and

The total drying times becomes

$t = (w_o - w_c) /R_c + W_c/R_c \times \ln (w_c/w)$ ---------- (4)

The above equation indicates that the time for complete drying from some initial moisture content w_o to a desirable final moisture content w depends on knowledge of critical moisture content w_c, the time for constant rate drying t_c, and the rate for constant drying R_c.

Experiment 4. Study of green house equipments.

List of greenhouse equipments:

1.Screens: It helps control the amount of light, humidity and temperature inside the facility, which turns to an improvement of the crop conditions and a reduction of the energy costs.

The screen has a flexible and easily-folding structure that once folded takes up minimum space and allows entering the maximum amount of light.

It may be automatically run by means of a solar radiation sensor.

Hot air heating: The hot air generators are especially recommended in those cases where there is not an important requirement for continuous heating and as an occasional defence againstfreezing temperatures. The purpose of this system is to increase the productivity of the crops and their maturity in cold weather, using medium level technology.

The distribution of hot air is carried out using fans and hoses.

Water heating: This is a Centralised heat generation system using natural gas, diesel, biomass, geothermal heat. Water circulates through metal or PVC-Polyethylene pipes as a heat transporting agent, depending on the temperature of the hot water source, the temperatureincrease requirements and the crop.

We offer a wide range of solutions in this area, from basic systems, to the most sophisticated systems with Open Buffer heat storage systems and use of CO_2 coming from combustion gases.

Extractor fan: The extractor fans allow forcing the ventilation inside greenhouses when the natural ventilation using roof and/or perimeter vents, does not allow reaching the desired rate of air renewal, which is an innate need for producing crops as well as livestock farms.

They are often used in combination with evaporative cooling panels or water misting systems for the purpose of obtaining a certain level of cooling.

Air circulation fan: The air circulation fans or recirculation fans help obtain a suitable air movement contributing to maintain a homogeneous interior climate, avoiding hot airaccumulation at the upper section of the greenhouse, reducing substantially the degree of water condensation and favouring the crops’ transpiration and CO_2 absorption.

They may be used as support for the extractor fans or as humidifier systems or for applying treatments.

Cooling: This water evaporation cooling system is comprised of extractor fans and cooling panels installed on opposite walls of the greenhouse to create a negative pressure area inside the greenhouse. This forces the outside air flowing through the dampened panels becoming charged with water molecules and cooled down and thus decrease the temperature inside the greenhouse.

Fertigation: Fertigation consists of applying simultaneously water and fertilizers through the irrigation system, supplying the nutrients required by the crops to the soil or substrate. Fertigation is especially useful in the case of drip irrigation. By means of automatic high technology fertigation equipments the water and the nutrients are perfectly placed in the absorption area of the roots, improving the rate of growth and quality of the crops.

This system allows carrying out a more rational use of the water and fertilizers, respecting the environment and minimizing the environmental impact.

Growing benches: The growing benches may be fixed, mobile or transportable.

Fix benches have a standard working height of 80cm.

The transportable benches include multi-direction wheels with brakes. Mobile benches allow moving the bench platform sideways on the structure, which facilitates creating aisles to access the benches, thus optimising the surface used for the growing.

Depending on the purpose for which the bench is used, any of the above-mentioned models can be selected with metallic grid bottom or an ebb and flow bottom.

Fog system: Consists of incorporating a large number of micro-particles of water to the ambient air, which remain suspended in the air inside the greenhouse long enough to evaporate without wetting the crops. The water is added in the form of fog using special nozzles distributed uniformly all over the surface of the greenhouse.

The Fog system is very useful for humidifying and cooling down the greenhouse in a controlled manner and carrying out disinfection treatments using soluble plant protection products.

Inflatable roof: The double inflated film system consists of creating an air chamber between two layers of plastic. The air chamber is kept inflated using small fans that inject air into the chamber via PVC and flexible pipes.

This air chamber reduces the heat transmission coefficient towards the outside, achieving a considerable energy savings and temperature control.

This system may be used on roofs as well as along the perimeter.

Climate control: offers a wide range of climate controllers for the automated management of all the systems that are installed in our greenhouses.

The controllers are guided by the information collected by the different sensors installed, in order to maintain suitable levels of solar radiation, temperature, relative humidity and CO_2 concentration for the crop; thus achieving the best evolution of the crops regarding their performance, early maturity and quality.

Experiment 5. Visit to various Post Harvest Laboratories.

Visit to RKM, Morabadi (Ranchi)

Experiment 6. Determination of Moisture content of various grains by oven drying & infrared moisture methods.

Moisture: Moisture content was estimated using A.O.A.C. (2006) method. Accurately weighed 5 g sample was taken in previously dried and weighed petri dish. The petri dish along with sample was placed in the oven maintained at 85±1°C for 3 to 4 h, by repeating the process of drying, cooling in the desiccator and weighing at 30 min intervals, until the difference between consecutive weights was less than 1mg. Then it was transferred to desiccators and cooled and weighed. The percent moisture content was calculated as:

$$\text{Moisture content (\%)} = \frac{W_2 - W}{W_1 - W} \times 100$$

Where; W = Weight of empty petri dish

W_1 = Weight of petri dish with sample before drying

W_2 = Weight of petri dish with sample after drying to constant weight

Infra-Red moisture meter:

The near infrared reflectance, NIR or IR, technique is a widely used technology for online moisture testing. Its popularity is due in large part to the ease with which it can be applied.

A light source (typically quartz halogen bulb) is collimated and filtered into specific wavelengths. The filters, mounted in a rotating wheel, chop the light into a series of pulses of specific wavelength. The filtered beam is directed onto the surface of the product to be measured. A portion of the light is reflected back to a detector (usually lead sulfide). Specific wavelengths of light are absorbed by water. If the filters are chosen such that one wavelength will be absorbed by water (sample beam) and one wavelength will be unaffected by water (reference beam), then the amplitude ratio of the two reflected wavelengths will be proportionate to the amount of water in the product. The ratio technique eliminates effects of product distance and source aging.

- Ease of application. Typically mounted 6 to 10 inches above product. Moderate product height variations have little influence on measurement.
- Small spot measurement area in conjunction with scanning frame provides product profile.
- Specific wavelengths may be chosen to measure variables other than moisture.

Experiment 7. Determination of engineering properties (shape and size, bulk density and porosity of biomaterials).

1. Grain size and shape

Grain size and shape (length-width ratio) is a very stable varietal property that can be used to measure the varietal purity of a sample. Comparing the length-width ratio of the sample with a published ratio for the variety will give an indication of varietal purity of the grain sample. A significant deviation means that the sample is impure – that is, it is either a different variety or a mixture of varieties.

Scale (length, mm)
Extra long (more than 7.5)
Long (6.6 to 7.5)
Medium (5.51 to 6.6)
Short (5.5 or less)

Scale	Shape	Length-width ratio
1	Slender	3.0
3	Medium	2.1 – 3.0
5	Bold	1.1 – 2.0
9	Round	Less than 1.1

Obtain a random sample from the seed batch.

Collect 20 grains at random from this sample of seed.

Use a Vernier caliper or photographic enlarger to measure the dimensions of each grain.

2. 1000 grain weight

Each variety has a published weight for 1000 grains. If the 1000-grain weight calculated from the sample departs from this, it may be an indication that the sample contains a mixture of varieties.

Select a random sample from the seed batch

Count 1,000 whole grains from the sample.

Weigh the 1,000 grains.

3. Bulk Density

Bulk density was determined by liquid displacement method. Fifty ml distilled water was taken in the measuring cylinder and volume was noted. Fifty g seeds were weighed accurately and transferred to the cylinder. Increase in volume of water was recorded to calculate bulk density and expressed as g/cc.

4. Hydration Capacity

Seeds weighing 10 g were counted and transferred to a measuring cylinder. To this 30 ml water was added and cylinder was covered with aluminum foil and left overnight at room temperature. Next day, seeds were drained, superfluous water was removed with filter paper and swollen seeds were reweighed.

$$\text{Hydration capacity (\%)} = \frac{\text{Increase in weight x100}}{\text{Weight (g) of seeds}}$$

$$\text{Hydration capacity (per seed)} = \frac{\text{Increase in weight}}{\text{Number of seeds}}$$

5. Hydration index

Hydration index was calculated using the following formula:

$$\text{Hydration index} = \frac{\text{Hydration capacity per seed}}{\text{Weight (g) of one seed}}$$

6. Swelling capacity

Seeds weighing 10 gm were counted and their volume was noted and soaked overnight. The volume of soaked seeds were noted in graduated cylinder.

$$\text{Swelling capacity (\%)} = \frac{\text{Increase in volume x100}}{\text{Weight (g) of seeds}}$$

$$\text{Swelling capacity (per seed)} = \frac{\text{Volume after soaking-Volume before soaking}}{\text{Number of seeds}}$$

7. **Swelling index**

Swelling index was calculated using the formula:

$$\text{Swelling index} = \frac{\text{Swelling capacity per seed}}{\text{Seed volume (ml)}}$$

8. Porosity: (inter granular space):

Introduction and Definition: Total porosity is defined as the fraction of the bulk rock volume V that is not occupied by solid matter. If the volume of solids is denoted by Vs, and the pore volume as Vp = V - Vs, we can write the porosity as:

$\phi = V - V_S/V = V_P/V$

Pore Volume/Total Bulk Volume

The porosity can be expressed either as a fraction or as a percentage. Two out of the three terms are required to calculate porosity. It should be noted that the porosity does not give any information concerning pore sizes, their distribution, and their degree of connectivity. Thus, rocks of the same porosity can have widely different physical properties. An example of this might be a carbonate rock and a sandstone. Each could have a porosity of 0.2, but carbonatepores are often very unconnected resulting in its permeability being much lower than that of the sandstone.

Laboratory Determinations: There are many methods for measuring porosity, a few of which will be discussed below. Several standard techniques are used. In themselves these are basic physical measurements of weight, length, and pressures. The precision with which these can be made on plugs is affected by the nature (particularly surface texture) of the plugs.

1 Direct Measurement Here the two volumes V and Vs are determined directly and used in Eq. (1). This method measures the total porosity, but is rarely used on rocks because Vs can only be measured if the rock is totally disaggregated, and cannot, therefore, be used in any further petrophysical studies. This measurement is the closest laboratory measurement to density log derived porosities.

2 Imbibition Method The rock sample is immersed in a wetting fluid until it is fully saturated. The sample is weighed before and after the imbibition, and if the density of the fluid r is known, then the difference in weight is r Vp , and the pore volume Vp can be calculated. The bulk volume V is measured using either vernier callipers and assuming that the sample is perfectly cylindrical, or by Archimedes Method (discussed later), or by fluid displacement using the saturated sample. Vp and V can then be used to calculate the connected porosity. This is an accurate method that leaves the sample fully saturated and ready for further petrophysical tests. The time required for saturation depends upon the rock permeability.

Experiment 8. Determination of Moisture content of various grains by moisture meter.

Moisture meters: All commonly used methods are based on electrical property of beans. An electrical current unit, resistance or capacitance, is measured and then converted into moisture content.

Resistance: the meter measures the electrical resistance of beans when a current is applied between two electrodes. Beans are placed in a constant and known volume.

Capacitance: the meter measures an electrical current between two plates of a condenser which constitute the walls of a recipient. A precise weight of sample is required. In both techniques, temperature corrections are required for accurate measurements. Most of moisture meters are equipped with temperature correction software.

Limits of the method: calibration charts must be established for each grain type. This means that a meter must be calibrated separately for robusta beans and arabica beans, but also for cherries and parchment to obtain accurate measurements. Accurate measurements are obtained within a range given by the manufacturer. Over this range, readings have no meaning.

LOSS ON DRYING MOISTURE METER METHOD (LOD):

The original primary moisture measurement method was Loss On Drying (LOD). In an LOD test, the sample is weighed, dried, and weighed again. The difference in the two weights (Loss on Drying) is then compared with either the original weight (Wet-base test) or final weight (Dry-base test) and the moisture content calculated. Tests can be manually conducted (weigh, oven dry, weigh) or automated (integrated weight and heating unit) with systems called Moisture Determination Balances. Depending on the balance and heating mechanism, a wide array of precision and accuracy is available. Today there are even micromoisture analyzers, using microbalances that can provide moisture measurement to the PPM level, consistent with the limits of KF testing.

Drawbacks of LOD test method are that it is destructive, meaning the sample is altered by the heating. In addition, it may be time-consuming with some tests taking 30 minutes or more to complete. Further, the test makes the assumption that all weight loss is due to water. In cases where substantial other volatiles (organics) are also available, this may not be the truth. Therefore, the results will overstate the moisture content and the test temperatures must be keptlow to avoid excessive loss of these “non-water” based components. Lowering the temperature increases the test time. Finally, the samples are dried with people involved. Where there is heat involved, safety and labor costs may become a concern.

Experiment 9. Field visit to seed processing plant

Visit to ICAR-RCER, (Palandu, Ranchi)

PRACTICAL MANUAL
AGS-603
Diseases of Field and Horticultural Crops and their Management-II

CONTENTS

Ex No	Date	Title of the Exercise	Date of submission	Grade	Sign
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

Ex.No.1. **DISEASES OF WHEAT**

Date:

1. Black Rust / Stem Rust

Symptoms

On wheat

- Initially, brick red colored elliptical blisters or pustules, known as uredia, develop on the stem, leaf and leaf sheath.
- The epidermis covering the pustules is later ruptured irregularly exposing a powdery mass of brick red-colored uredospores.
- At the end of the crop season, the pustules turn black as the fungus produces teliospores.

On barberry

- On the upper side of leaf, a few minute, orange-colored bodies, the spermagonia, are formed bearing a small droplet of liquid or nectar.
- Beneath the spermagonia, groups of orange-yellow cuplike aecia appear.
- The infected host tissue is frequently swollen.

Pathogen: *Puccinia graminis* f. sp. *tritici*

- The fungus produces well branched, dikaryotic, intercellular mycelium and haustoria. It is an obligate biotroph, macrocyclic and heteroecious.
- On wheat, the fungus produces uredial, Telial and basidial stages and on alternate host Barberry, it produces pycnial and aecial stages
- The urediospores are produced repeatedly from the same mycelium or from the urediospores by clonal multiplication.
- Thus urediospores are called repeating spores and are considered as asexual spores.The uredospores are brown, oval, one celled, pedicellate, with four equatorial germpores.
- The teleutospores (teliospores) are dark or chestnut brown, two-celled, pedicellate, smooth walled and pointed apex.
- The basidiospores are unicellular, round and uninucleate. Basidiospores infect barberry plant.
- The pycnia are produced on the upper surface of the barberry leaf. They are flask-shaped and ostiolate.
- The aecia are produced on the lower surface of barberry leaf.

2. Brown rust / orange rust /
leaf rustSymptoms:

- Small circular to oval shaped, orange to brown colored pustules (representing the formation of uredia) are scattered on both the upper and the lower leaf surfaces.
- *Thalictrum* and *Isopyron* species are alternate hosts

Pathogen: *Puccinia triticina* (formerly *P. recondita)*

- Characters are the same as described in *P. graminis tritici*. But the differentiating feature is teleutospores that are two celled, with a rounded and thickened apex

3. Yellow rust / stripe rust

Symptoms:

- Yellow-colored pustules are produced between veins on leaf and arranged in linear rows and hence it is called stripe rust.
- The pustules consist of uredosori exposing a large number of uredospores.
- Alternate host –*Berberis* spp. and *Mahonia*

Pathogen: *Puccinia striiformis* f. sp. *tritici*

- Characters are the same as described in *P. graminis tritici*. But the differentiating feature is teleutospores which are two celled, thick walled and flattened at the top.

4. Loos e Smut

Sympto ms:

- Disease is seen in the ear head stage. Diseased ear heads emerge out of the boot leaf earlier than healthy ones.
- Usually all spikelets are affected and transformed into a mass of black powdery spores. Each spikelet is covered by a thin silvery membrane, which breaks while the earhead emerges.
- The powdery mass of spores is blown off by wind or removed by rain leaving behind only the central rachis.

Pathogen: *Ustilago nuda tritici*

- It produces unicellular pale, olive-brown, spherical to oval, minute, echinulated smut spores (chlamydospores) in the affected earheads.

5. Powdery Mildew

Symptoms:

- A greyish white powdery growth appears on the upper surface of the leaf, leaf sheath and inflorescence.
- With advancement of the disease, several black dots representing the cleistothecia formation on the affected plant parts

Pathogen: *Blumaria graminis* var. *tritici*

- Thallus is filamentous, hyaline, septate mycelium. Mycelia are epiphytics (ectoparasites) on the surface of the leaves and pathogens absorbs the nutrients by producing haustoria from the superficial mycelium into the epidermal cells.

- Asexual spore is conidium. Conidiophore is short, club shaped, unbranched, non-septate and hyaline. Conidia are barrel shaped, single celled, hyaline, produced in chain.
- Sexual fruiting body is chasmothecium contains ascus and ascospores (sexual spores) are produced.

6. Flag Smut Symptoms:

- The fungus attacks leaf, stem and earheads. Symptoms appear anytime from seedling stage to the ear formation.
- Greyish black linear sori occur on the leaf blade and leaf sheath.
- The sorus contains black powdery mass of spores. Infected plants are stunted in growth and bear twisted leaves, that droop down giving flagging symptom.

Pathogen: *Urocystis agropyri*

- The spores are aggregated into balls consisting of a dark fertile entre, surrounded by a ring of lighter coloured sterile cells.
- Each spore ball contains 1 to 6 number of brown, globose, smooth walled spores (called smut spores/teliospores).
- Each smut spore germinates into promycelium which produces 2-6 cylindrical basidiospores terminally.
- Basidiospore germinates to produce primary mycelium. Opposite mating type primary mycelia fuse and form dikaryotic secondary mycelium that become systemic.
- Dikaryotic mycelium later forms black stripes of smut sori.

7. Rough bunt/ Common bunt/stinking bunt/hill buntSymptoms

- Symptoms evident only at heading stage though it infects the seedlings (systemic infection).
- Infected plants are shorter and produce smutted grains that emit a fishy stink smell. Hence the disease is called stinking smut.
- This stinking/foul smell is due to a volatile compound called trimethylamine produced by the fungus.
- The smut sori in the smutted grains are covered with membrane made up of host tissue and the teliospores from the sori are released only at the time of thrashing.

Pathogen: *Tilletia caries/ T. laevis*

- *Tilletia caries* produces rough walled teliopsores and *T. laevis* produces smooth walled teliospores.
- Upon germination, teliospores germinate to produce non- septate promycelium (holobasdium type) which again produce 8-16 cylindrical basidiospores formed terminally.
- Basidiospores of opposite mating type fuse in situ, forming characteristic H shaped structures leading to the formation of dikaryotic hyphae.

- A short dikaryotic hypha infects the host or it forms a cresecent shaped binucleate secondary sporidium which again germinate to produce dikaryotic hypha.

8. Karnal bunt/partial bunt

Symptoms

- The symptom occurs at the time of earhead formation.
- Few grains are smutted and that too these grains are partially (that is why, it is called as partial bunt) converted into black powdery mass of smut sorus.
- Embryo is not affected and such grains can germinate.

Pathogen: ***Tilletia indica*** **(Syn:** ***Neovossia indica)***

- Teliospores are dark brown, spherical to oval shaped. Spores germinate to form a short stout non-septate promycelium at the apex of which several filiform basidiospores are formed.

9. Ergot

Symptoms

- The first symptoms appear as creamy droplets of a sticky liquid exuding from young florets of infected heads (Honey dew).
- The droplets are soon replaced by a hard, horn-shaped, purplish-black sclerotia or ergots that grow in place of the kernel (kernal is replaced by sclerotia)

Pathogen: ***Claviceps purpurea***

- It is a biotroph, non-systemic with high organ specificity that is it infects only the ovary of the cereals and entire ovary is converted into sclerotia in place of normal seed development from the ovary.
- The pathogen infects the florets, grows through the stylar tube to the base of the ovary where it ramifies the entire ovary tissue and depends on the living host plant tissue (biotroph).
- The fungus produces conidia on asexual fruiting body- sporodochia.
- The sexual spores are ascospores that are produced in perithecium. The fungi survives in the form of sclerotia

10. Fusarium head blight / scab

Symptoms

- Generally, *Fusarium* spp infect root and cause vascular infection. But *F.graminearum* infects mainly inflorescence and damages the grains. Similarly, *F.verticillioides* also infects the wheat ear head. Both these two species of *Fusarium* mainly infects the inflorescence and root infection is uncommon.
- Premature bleaching of one or more spikelets or the entire immature wheat ear head is the common symptom. The bleaching can start anywhere on the ear head and spread until the entire

ear head is bleached.

- Bleached spikelets are sterile or contain shriveled and/or discolored seed. During humid conditions, white or pink fungal growth with orange spore masses may be seen on bleached spikelets.
- Blue-black colored perithecia are formed, giving the ear head a scabbed appearance, hence

the name scab.

- *F. graminearum* produces a toxin, deoxynivalenol (DON, vomitoxin), a serious mycotoxin

Pathogen: *Fusarium graminearum (Gibberella zeae)*

- Thallus is hyaline, septate, filamentous mycelium.
- During asexual reproduction, it produces macro conidia and chlamydospores. It does not produce micro conidia.
- During sexual reproduction, it produces sexual fruiting body perithecia and ascospores

11. Tundu / Yellow

Ear RotSymptoms:

- The characteristic symptom of the disease is the formation of yellow slime on the stem and inflorescence.
- It dries up to form sticky yellow layers and cause curling and twisting of the spikes.
- Galls formed by the nematodes replace most of the grains in the ear head.

Causal organisms: *Rathayibacter tritici*

- The bacterium is rod shaped, pleomorphic and frequently exhibit club shaped swellings, Gram positive and motile by a polar flagellum
- Nematode, *Anguina tritici*, is the vector of the bacterium *Rathayibacter*.

Minor diseases

1.* Tan spot – *Pyrenophora tritici-repentis

- Tan colored and dimond shaped spots surrounded with yellow halo are formed on the leaf.
- When plant matures, the fungus invades the straw and produce black colored raised fruiting bodies called pseudothecia are formed.

2.* Take all disease -*Gaeumannomyces graminis* var. *tritici

- Take-all first becomes apparent near the time when the seed head emerges.
- The leaves are yellow and plants may be stunted.
- The disease usually occurs in circular patches although it also can be fairly uniform throughout a field.
- The most diagnostic field symptom is prematurely-ripe tillers

***3.* Foot Rot -** *Pythium graminicolum* and *P. arrhenomanes*

Symptoms:

- The disease mainly occurs in seedlings and roots and rootlets become brown in colour.
- Seedlings become pale green and have stunted growth.
- The collar region becomes discoloured and soft
- The leaf sheaths turn blackish brown and split into shreds.

DISEASES OF CHICKPEA

1. Wilt

Symptoms

- The disease occurs at two stages of crop growth, seedling stage and flowering stage.
- The main symptoms on seedlings are yellowing and drying of leaves, drooping of petioles and rachis, withering of plants.
- In the case of adult plants drooping of leaves is observed initially in upper part of plant, and soon observed in entire plant.
- Vascular browning is conspicuously seen on the stem and root portion

Pathogen: ***Fusarium oxysporum fsp ciceri***

- The fungus produces hyaline to light brown, septate and profusely branched hyphae.
- Micro conidia are oval to cylindrical, hyaline, single celled, normally arise on short conidiophores.
- Macro conidia which borne on branched conidiophores, are thin walled, 3 to 5septate, fusoid and pointed at both ends.
- Chlamydospores are rough walled or smooth, terminal or intercalary, may be formed singly or in chains.

2. Ascochyt a blight

Symptoms

- All above ground parts of the plant are infected. On leaf, the lesions are round or elongated, bearing irregularly depressed brown spot and surrounded by a brownish red margin.
- Similar spots may appear on the stem and pods. The spots on the stem and pods have pycnidia arranged in concentric circles as minute block dots.
- When the lesions girdle the stem, the portion above the point of attack rapidly dies. If the main stem is girdles at the collar region, the whole plant dies.

Pathogen: ***Ascochyta rabiei***

- The fungus produces hyaline to brown and septate mycelium.
- Pycnidia are spherical to sub-globose with a prominent ostiole.
- Pycnidiospores are hyaline, oval to oblong, straight or slightly curved and single celled, occasionally bicelled.

3. Rust

Symptoms

- Infection appears as small oval, brown, powdery lesions on both the surface, especially more on lower surface or leaf.
- The lesions, which are uredosori, cover the entire leaf surface. Late in the season, dark teliosori appear on the leaves.
- The rust pustules may appear on petioles, stems and pods. The pycnial and aecial stages are unknown

Pathogen: ***Uromyces ciceris-arietini***

- The uredospores are spherical, brownish yellow in colour, loosey echinulated with 4-8 germ pores.
- Teliospores are round to oval, brown, single celled with unthickened apex and the walls are rough, brown and warty.

4. Dry root rot

Symptoms

- The pathogen is seed-borne and primarily causes seedling blight and collar rot in the initial stages. The grown up plants also show symptoms after flowering stage.
- The infected plants show drooping of leaves and death occurs in patches.
- The bark of the lower stem and roots shreds and are associated with a large number of sclerotia.
- Dark coloured, minute pycnidia also develop on the lower portion of the stem.

Pathogen: ***Rhizoctonia bataticola***

- The fungus produces a large number of black, rounds to irregular shaped sclerotia.
- The pycnidia are dark brown to black with an ostiole and contain numerous single celled, thin walled, hyaline and elliptical pycnidiospores.

5.* Wet root rot: *Rhizoctonia Solani

Symptoms:

- The infected seedling slowly turn yellow and petioles and leaflets show drooping symptoms that leads to complete drying of the plant.
- The stem near the collar region shows rotting symptom.

Pathogen:

- The hyphae of the fungus are dark brown, filamentous and septate with constrictions.
- The sclerotia are brown and irregular in shape.
- The fungus has its sexual stage. *Thanephorus cucumeris,* which produces 2-4 basidiospores in terminal clusters on a short called hypha.

6. Collar rot

Symptoms

- It comes in the early stages i.e up to six weeks from sowing. Drying plants whose foliage turns slightly yellow before death, scattered in the field is an indication of the disease. Seedlings become chlorotic.
- The joint of stem and root turns soft slightly contracts and begins to decay.
- Infected parts turn brown white. Black dots, like mustard in shape known as sclerotia are seen appearing on the white infected plant parts.

Pathogen: ***Sclerotium rolfsii***

- Fungus produces white cottony radiating mycelia with mustard seed like sclerotia on the infected plant parts

7. Stunt disease

Symptoms

- Affected plants are stunted and bushy with short internodes.
- The leaflets are smaller with yellow, orange or brown discoloration. Stem also shows brown discoloration. The plants dry prematurely.
- If survive, a very few small pods are formed. Phloem browning in the collar region is the most characteristic symptom of the stunt, leaving xylem normal.

Pathogen: Chlorotic stunt virus

- The virus is transmitted by *Aphis craccivora*

DISEASES OF LENTIL

1. Fusarium Wilt

Symptoms:

- It usually occurs near or at the reproductive stages (flowering to pod-filling) of crop growth.
- Symptoms include the drooping and wilting of the uppermost leaflets and discolouration of the vascular system. Plants become completely yellow and die.
- When the plants are affected during the mid- to late-pod filling stages, seeds are often shriveled

Pathogen: ***Fusarium oxysporum*** **f.sp.** ***lentis***

- The fungus produces hyaline to light brown, septate and profusely branched hyphae.
- Micro conidia are oval to cylindrical, hyaline, single celled, normally arise on short conidiophores.
- Macro conidia which borne on branched conidiophores, are thin walled, 3 to 5septate, fusoid

and pointed at both ends.

- Chlamydospores are roughwalled or smooth, terminal or intercalary, may be formed singly or in chains

2. Ascochyta blight

Symptoms

- The symptoms of the disease include lesions on leaves, petioles, stems and pods.
- The irregularly shaped lesions on leaves, petioles and stem are tan and darker brown on pods and seeds.
- Black pycnidia are visible in the centre ofmature/older lesions. In severe infection, lesions can girdle the stem, leading to breakage and subsequent death of all tissues above the lesion.
- Heavily infected seeds are shriveled and discoloured with whitish mycelium and pycnidia

Pathogen: ***Ascochvta lentis***

- The asexual stage is characterized by the production of pycnidia in the lesions on infected plants, the pycnidia release conidia which are cylindrical, straight or rarely curved, round at the ends with a median septum.
- The teleomorph *(Didvmella lentis)* was observed for the first time on over wintered lentil straw which produced fertile pseudothecia and viable ascospores.

3. Rust

Symptoms

- Rust starts with the formation of yellowish-white pycnia and aecial cups on the lower surface of leaflets and on pods, singly or in small groups in a circular form.
- Later, brown uredial pustules emerge on either surface of leaflets, stem and pods. Pustules are oval to circular. They may coalesce to form larger pustules.
- The telia, which are formed late in the season, are dark brown to black, elongated and present mainly on branches and stems.
- In severe infections leaves are shed and plants dry prematurely and the affected plant dries without forming any seeds in pods or with small shriveled seeds.

Pathogen: *Uromyces viciae-fabae*

- It is an autoecious fungus, completing its life cycle on lentil.
- The aecia of are formed usually in groups surrounding the pycnia or sometimes scattered, cupulate. The aeciospores are spheroidal, wall hyaline, verrucose.
- Uredia are amphigenous and on the petioles and stems, scattered, cinnamon color. Uredospores are ellipsoidal with very finely echinulations.
- Telia are like the uredia but black and larger. Teliospores are ellipsoidal chestnut brown colored , and smooth

DISEASES OF SUNFLOWER

1. Root rot or charcoal rot

Symptoms

- The pathogen is seed-borne and primarily causes seedling blight and collar rot in the initial stages.
- The grown up plants also show symptoms after flowering stage. The infected plants show drooping of leaves and death occurs in patches.
- The bark of the lower stem and roots shreds and are associated with a large number of sclerotia.
- Dark coloured, minute pycnidia also develop on the lower portion of the stem.

Pathogen: ***Rhizoctonia bataticola*** **(Pycnidial stage*: Macrophomina phaseolina*)**

- The fungus produces a large number of black, round to irregular shaped sclerotia.
- The pycnidia are dark brown to black with an ostiole and contain numerous single celled, thin walled, hyaline and elliptical pycnidiospores.

2. Leaf blight

Symptoms

- The pathogen produces brown spots on the leaves, but the spots can also be seen on the stem, sepals and petals.
- The lesions on the leaves are dark brown with pale margin surrounded by a yellow halo.
- The spots later enlarge in size with concentric rings and become irregular in shape.
- Several spots coalesce to show bigger irregular lesions leading to drying and defoliation.

Pathogen: ***Alternaria helianthi***

- The pathogen produces cylindrical conidiophores, which are pale grey-yellow coloured, straight or curved, geniculate, simple or branched, septate and bear single conidium.
- Conidia are cylindrical to long ellipsoid, straight or slightly curved, pale grey-yellow to pale brown, 1 to 2 septate with longitudinal septa.

3. Downy Mildew

Symptom

- First symptoms are yellowing of the first pair of true leaves.
- Sunflower plants carrying systemic infection are severely stunted and leaves are entirely chlorotic.
- Affected plants bear abnormally thick, downward curled leaves showing prominent yellow and green mottling.
- The stem becomes brittle. Small angular greenish yellow lesions may appear on leaves as a

result of secondary infection. Fungal growth is visible at lower surface.

Pathogen: ***Plasmopara halstedii***

- Obligate biotroph produces intercellular mycelium with haustoria.
- During asexual reproduction, it produces right angle branched sporangiophore with hyaline, oval shaped, thin walled sporangia.
- During sexual reproduction, the fungus produces oospores with long dormancy

4. Rust

Symptoms:

- Small, reddish brown pustules (uredia) covered with rusty dust appear on the lower surface of bottom leaves.
- Infection later spreads to other leaves and even to the green parts of the head.
- In severe infection, when numerous pustules appear on leaves, they become yellow and dry.
- The black coloured telia are also seen among uredia on the lower surface.
- The disease is autoecious rust. The pycnial and aecial stages occur on volunteer crops grown during off-season.

Pathogen: ***Puccinia helianthi***

- The uredospores are round or elliptical, dark cinnamon-brown in colour and minutely echinulated with 2 equatorial germpores.
- Teliospores are elliptical or oblong, two celled, smooth walled and cheshnut brown in colour with a long, colourless pedicel.

5. Head rot/

Capitulum rot

Symptoms

- The affected heads show water soaked lesions on the lower surface, which later turn brown
- The discoloration may extend to stalk from head. The affected portions of the head become soft and pulpy and insects are also seen associated with the putrified tissues.
- The larvae and insects which attack the head pave way for the entry of the fungus which attacks the inner part of the head and the developing seeds.
- The seeds are converted into a black powdery mass. The head finally withers and droops down with heavy fungal mycelial nets.

Pathogen: ***Rhizopus sp*****.**

- Pathogen produces dark brown or black coloured, non-septate hyphae.
- It produces many aerial stolens and rhizoids. Sproangia are globose and black in colour with a central columella.
- The sporangiospores are aplanate, dark coloured and ovoid.

6. **Powdery mildew**

Symptoms

- The disease produces white powdery growth on the leavesWhite to grey mildew on the upper surface of older leaves.
- As plant matures black pin head sized are visible in white mildew areas.
- The affected leaves more luster, curl, become chlorotic and die.

Pathogen: ***Golovinomyces cichoracearum***

- The fungus produces ectophytic, branched, septate mycelium.
- During asexual reproduction, it produces hyaline, cylindrical, thin walled, single celled conidia in chain on a short club shaped conidiophores

7. **Basal rot**

Symptoms

- Initial symptoms of the disease appear 40 days sowing.
- The infected plants can be identified by their sickly appearance. Plants dry up due to the disease infestation.
- The lower portion of stem is covered with white or brownish white fungal colonies. In extreme cases the plants wilts and dies.
- Dark brown lesions appear on the base of the stem near ground level, leading to withering. Large numbers of sclerotia are seen.

Pathogen: ***Sclerotium rolfsii***

- It is a necrotrophic fungal pathogen produces hyaline, septate, branched radiating mycelium.
- It produces numerous small brown colored mustard seed like sclerotia with high degree of dormancy

8. **Necrosis -Tobacco streak virus (TSV)**

Symptoms:

- mosaic on leaves that leads to extensive necrosis of leaf lamina, petiole, stem, floral calyx and complete death of seedlings
- Early infection either kills the plant or causes severe stunting with malformed head filled with chaffy
- seeds Necrosis at bud formation stage makes the capitulum to bend and twist Complete failure of seed setting and maturation.

Pathogen: Tobacco streak virus

- It is an *Ilarvirus* with 25-28 nm, tripartite genome encapzidated separately.
- Virus spreads through thrips *Frankliniella schultzii*.

DISEASES OF MUSTARD

1. Alternaria blight

Symptoms

- The disease attacks on the lower leaves as small circular brown necrotic spots which slowly increase in size.
- Many concentric spots coalesce to cover large patches showing blightening and defoliation in severe cases.
- Circular to linear, dark brown lesions also develop on stems and pods, which are elongated at later stage.
- Infected pods produce small, discolored and shriveled seeds.

Pathogen: ***Alternaria brassicola*** **and** ***Alternaria brassicae***

- It is a necrotrophic fungal pathogen produced conidia formed in chains or solitary.
- The conidia are typically ovoid to obclavate, often beaked, pale brown to brown, multi-celled and muriform.

2. Wh
ite rust

Symptoms

- Both local and systemic infections are observed.
- In case of local infection, white creamy yellow raised pustules appear on the leaves which later coalesce to form patches.
- In systemic infection and during humid weather, mixed infection of white rust and downy mildew cause swelling and distortion of the stem and floral parts due to hypertrophy and hyperplasia and develop “stag head” structure

Pathogen: ***Albugo candida (Cystopus candidus)***

- The mycelium is intercellular that produces knob like haustoria in the host cells.
- The pathogen produces endogenous sporangia in chain.
- The sporangia germinate directly to produce mycelium and indirectly by producing zoospores.
- The pathogen perpetuates through the ornamented reticulate oospores lying in the diseased plant debris.

3. Downy Mildew

- Light green or slightly chlorotic lesions that become yellow or necrotic after sporulation.
- Lesions are angular and variable in size, but are often bounded by large veins.
- The bottom sides of leaves develop a fluffy or downy appearance from sporulation during cool, moist conditions.
- Old lesions become necrotic and translucent after invasion by secondary saprophytes.

- Seedlings may be killed or develop dark brown vascular systems from severe infections, but older plants are rarely killed.

Pathogen: ***Peronospora brassicae***

- It is an obligate parasite that produces intercellular mycelia with large finger shapedbranched haustoria,
- Numerous erect dichotomously branched sporangiophores with pointed sterigmata which bears hyaline, thin walled , spherical to oval shaped sporangia.
- The sporangia directly germinate and produces mycelium
- Under unfavourable condition , it produces thick walled dormant resting oospores

4. Powdery mildew

Symptoms

- Symptoms appear as dirty white, circular, floury patches on either sides of the leaves.
- Under favourable environmental conditions, entire leaves, stems, floral parts and pods are affected. The whole leaf may be covered with powdery mass

Pathogen: *Erysiphe cruciferarum*

- Mycelium of the fungus appears as small radiating and diffuses colonies of superficial white on the surface of the leaf.
- The conidia are singly produced (not in chains) and are ovoid to cylindrical in shape.
- The asci and ascospores are produced in chasmothecium.

5. Club root

Symptom

- Affected plants remain stunted.
- Tiny nodules to large club shaped outgrowths develop in the root system.
- Leaves turn pale green or yellow followed by wilting and under severe conditions the plants die.

Pathogen: ***Plasmodiophora brassicae***

- It is an obligate parasite belongs to protozoa.
- The vegetative thallus is plasmodium. It follows a special form of nuclear division i.e., cruciform division.
- It produces zoospores during asexual reproduction and resting spores during sexual reproduction.

6. Sclerotinia stem rot

Symptom

- Elongated water soaked lesions appear on stem near to the crown region, covered with cottony mycelial growth later on.
- Plant looks like whitish from distance at internodes or base.
- Premature ripening and shredding of stem, wilting and drying.
- Brown to black sclerotial bodies may also be seen on the infected plant parts.

Pathogen: ***Sclerotinia sclerotiarum***

- Mycelium of the fungus is hyaline, septate, branched and radiating on infected parts.
- The fungus produces hard, irregular, flattened sclerotia during asexual reproduction.
- The sclerotia germinate and produce apothecia with asci and ascospores

7. Bacterial blight/ black rot

Symptoms

- The leaf tissue turns yellow and chlorosis reach towards the centre of the leaf and form V shaped area with base of V towards the midrib. The veins show brown to black discoloration.
- Dark coloured streaks are formed on the stem from the ground level and gradually these streaks enlarge and girdle the stem.
- Stem become hollow due to internal rotting.
- Midrib cracking of lower leaves, browning of veins and withering is observed.
- In severe cases, the vesicular bundles of the stem also turn brown and the plant collapses.

Pathogen: ***Xanthomonas campestris pv campestris***

- It is a gram negative, rod shaped, soil bone bacterium with single polar flagellum.
- It produces yellow pigment xanthomonadin

8. Parasitic weed: Broomrape: ***Orobanche aegyptiaca*** **L.(Orobanchaceae)**

- Broomrape is an annual total root parasites lacking chlorophyll, upto 1 m tall.
- Usually parasitize solanaceae and fabaceae hosts reducing crop yield severely.
- Seeds germinate in response to host root exudates and the seedlings must come in contact with host rootimmediatelyafter germination.
- Some species mayproduce flowers withina week of emergence from the soil.
- Seeds of orobanche are irregular wedge shaped oblong, tiny dust like 0.2 to 0.5 mm long black to brown coloured.

Ex. No.3 **DISEASES OF COTTON AND SUGARCANE**

Date:

DISEASES OF COTTON

1. Fusarial wilt

Symptoms

- First symptoms on young seedlings are yellowing and browning of cotyledons, followed by brown ring on the petiole.
- Finally wilting & drying of the seedling occur. Infection at later stages includes lossof turgidity, yellowing, drooping and wilting, starting from older leaves.
- Browning or blackening of vascular tissues occur on the stem and spreads upwardsand downwards. Infected plants stunted with fewer bolls

Pathogen: *Fusarium oxysporum f.sp vasinfectum*

- The fungus produces three types of spores. Macroconidia are 1 to 5 septate, hyaline, thin walled, falcate with tapering ends.
- The microconidia are hyaline, thin walled, spherical or elliptical, single or two celled.
- Chlamydospores are dark coloured and thick walled.
- The fungus also produces a vivotoxin, Fusaric acid which is partially responsible for wilting of the plants.

2. Verticilium wilt

Symptoms

- If affects the crop in square and boll formation stages.
- Bronzing of veins followed by interveinal chlorosis, yellowing and scorching of leaves.
- It exhibits drying of leaf margins and areas between veins known as Tiger stripe symptom.
- Affected plants remain barren showing pinkish discolouration in stem and wood.
- It may produce smaller bolls

Pathogen: *Verticillium dahliae*

- The fungus produces hyaline, septate mycelium and two types of spores.
- The conidia are single celled, hyaline, spherical to oval, borne singly on verticillate conidiophores.
- The micro sclerotia are globose to oblong, measuring 48-120 X 26-45um.

3. **Root rot**

Symptoms

- Germinating seedling shows black lesions on hypocotyls, girdling of stem and death of seedling
- Affected basal stem becomes dark with bark shredding and scloretial bodies in the shredded bark
- The entire root system gets rotted, plants dried & can be easily pulled out

Pathogen: *Rhizoctonia bataticola*

- The fungal hyphae are septate and fairly thick and produce black, irregular minute sclerotic with mycelia attachment.

4. **Anthracnose : *Colletotrichum capsici***

- Small reddish circular spots on the cotyledons of the seedlings
- Collar region shows lesions leading to wilting and drying. In matured plants stem splitting and shredding of bark
- In bolls, water soaked reddish brown spots known as boll spotting leading to premature bursting and drying

Pathogen: *Colletotrichum capsici*

- The pathogen forms large number of acervuli on the infected parts.
- The conidiophores are slightly curved, short, and club shaped
- The conidia are hyaline and falcate, borne single on the conidiophores.
- Numerous black coloured and thick walled setae are also produced in acervulus.

5. **Grey or Areolate mildew**

- Irregular to angular pale translucent lesions on lower surface, bound by veinlets and grey powdery growth
- Light green specks on upper surface
- In severe cases whitish grey powdery growth on upper surface. Affected leaves dry up inward turn yellow and fall prematurely

Pathogen: *Ramularia areola*

- The fungus produces endophytic, septate mycelium. Conidiophores are short, hyaline and branched at the base. Conidia are borne singly or in chains at the tips of conidiophores.
- The conidia are hyaline, irregularly oblong with pointed ends, sometimes rounded to flattened ends, unicellular or 1-3 septate.
- The perfect stage of the fungus produces perithecia containing many asci. The ascospores are hyaline and usually two celled.

6. Boll rot

- Brown or black dots covering entire bolls
- Rotting may be internal or external
- Bolls do not open and fall prematurely

Pathogen: ***Fusarium moniliforme*; *Aspergillus flavus***

Fusarium moniliforme

- Mycelium - septate, hyaline, Conidiophore- slender, short, hyaline, simple, stout or branched irregularly.
- Two types of conidia – macroconidia (several celled, slightly curved or bent, pointed at the both the ends, sickle shaped), microconidia (1 or 2 celled, ovoid, single or in chains, hyaline) and also Chlamydospores : terminal or intercalary, produced singly or in chains by the mycelial hyphae or macroconidia.

Aspergillus flavus

- Mycelium*:* highly branched, septate. Conidiophore: characteristic symmetric or asymmetric broom like fashion.
- The first generation branches are called primary branches or rammi, on which whorls of second generation branches called metulae are produced.
- Each metula ultimately bears bottled shaped phialides which bears conidia in chains in basipetal succession. Conidia: globose, hyaline.

7. Leaf blight

- It affects all stages of crop. Initially, produces small, brown irregular to round spots with a central necrotic lesions which on coalesce form large blighted areas
- The affected leaves brittle and fall off. Symptoms are also in stems, bracts and bolls in severe cases

Pathogen: ***Alternaria macrospora***

- The fungus produces dark brown, short, 1-8 septate, irregularly bent conidiophores with a single conidium at the apex.
- The conidia are obclavate, light to dark brown in colour with 3-9 transverse septa and 4 longitudinal septa, with a prominent long beak.

8. Bacterial blight

- Water soaked, circular or irregular lesions on cotyledons which spread to petiole and stem and finally withering and death of seedling known as Seedling blight
- The infection of veins and veinlets shows blackening with crinkled and twisted leaves and bacterial oozing
- Black lesions on stem and branches, premature drooping off of the leaves resulting in die back known as Black arm. It also affects the bolls causing boll rot

Pathogen: ***Xanthomonas campestris p.v malvacearum***

- The bacterium is a short rod with a single polar flagellum. It is gram negative, non-spore forming and measures 1.0-1.2 X 0.7-0.9 µm.
- The bacterium is aerobic, capsule forming and produces yellow colonies in culture medium.

9. Stenosis (or) Small leaf:

- Affected plants stunted, produces smaller leaves in clusters due to profuse vegetative growth
- Leaves disfigured and flower with abortive ovary
- Premature dropping of flower buds and bolls
- Root system poorly developed
- Basal stem with short branches bearing small and cluster of deformed leaves

Pathogen: ***Candidatus Phytoplasma***

- Phytoplasma is found in the sieve cells of infected plants.
- Two types of bodies are noticed, spherical bodies of 300-400 nm diameter and filamentous bodies of 30-53 mm diameter.

10. Cotton leaf curl

Symptoms

- Leaves of infected cotton curl upward and bear leaf-like enations on the underside along with vein thickening.
- Plants infected early in the season are stunted and yield is reduced drastically.
- This virus devastated the Pakistan cotton industry in early 1990s where it caused an estimated yield reduction of 30-35%.

Pathogen: Cotton Leaf curl virus

- Cotton leaf curl virus (CLCuV) is a plant pathogenic virus species of the family *Geminiviridae*. It is a DNA virus.
- Vector: White fly *Bamisia tabaci*

DISEASES OF SUGARCANE

1. Red rot : *Colletotrichum falcatum*

Symptoms

- Drooping, withering, and finally yellowing of the 3rd or 4th upper leaves in the crown followed by wilting of the entire crown.
- Dark-reddish zones having tendency to elongate rapidly turning blood-red enclosed by dark margins.Reddening of internal tissue with white cross bands.
- Shrivelling of canes with black specks. Infected cane gives sour smell

Pathogen: ***Colletotrichum falcatum***

- The fungus produces thin, hyaline, septate, profusely branched hyphae containing oil droplets.
- The fungus produces black, minute velvetty acervuli with long, rigid bristlelike, septate pointed setae on the surface of rind, leaf midrib and sometimes in the pith region.
- Conidiophores are closely packed inside the acervulus, which are short, hyaline and single celled. The conidia are single celled, hyaline, falcate, granular and guttulate.
- perfect stage of the fungus produces large number of globose and dark brown to black perithecia with a papillate ostiole. Asci are clavate, unitunicate and eight spored.
- Large number of hyaline, septate, filiform paraphyses is also present among asci. Ascospores are ellipsoid or fusoid, hyaline, straight or slightly curved and unicellular

2. **Smut**

Symptoms

- It is a Culmiculous smut.The central shoot converted into long whip like dusty black structure
- Whip covered by white papery membrane, in maturity membrane ruptures and liberates smut spores (Teliospores)
- Mummified arrows

Pathogen: ***Ustilago scitaminea***

- The fungal hyphae are primarily intercellular and produce tiny black teliospores.
- The thin membrane which covers the smut whip represents the host epidermis.
- The smut spores are light brown in colour, spherical and echinulate.
- Smut spores germinate to produce 3-4 celled, hyaline promycelium and produce 3-4 sporidia which are hyaline and oval shaped with pointed ends.

3. Sett rot or Pineapple disease

Symptoms

- Affected tissues are reddish colour later turns black
- Internal cavities formed due to rotting of internal tissues
- Affected setts produce sweet pine apple odour
- Infection reduced the germination of setts which results in the gap in the field

Pathogen: *Ceratocystis paradoxa*

- Conidia : micro conidia (young-hyaline, maturity-black, thin walled, cylindrical form, endogenously produce chain of conidia) and macro conidia (exogenously produced chain of conidia ,spherical , elliptical, truncate or pyriform , hyaline to olive green or black color.
- Perithecia are gregarious and flask shaped with a long narrow beak. Asci are clavate and the ascospores are convex to elliptical.

4. Rust

Symptoms

- Minute, elongated, yellow spots (uredia) appear on lower surface of young leaves. Later the pustules appear on upper surface also. The pustules turn brown on maturity.
- Late in the season, dark brown to black telia appear on the lower surface of leaves. In severe cases, the uredia also appear on the leaf sheath and the entire foliage looks brownish from a distance.
- The disease affects cane yield and reduces juice quality.

Pathogen: *Puccinia erianthi*

- The mycelium is hyaline, branched and septate. P.kuehnii produces ovoid or pear shaped, single celled uredospores with apical thickening and golden yellow in colour.
- Teliospores are produced in abundance, which are pale to brick colour, two celled, smooth walled and slightly constricted at septum.
- Occurrence of pycnial and aecial stages and the role of alternate host are unknown.

5. Pokkah Boeng

Symptoms

- Development of disease symptom in four phases was observed namely chlorotic phases I and II, top rot and knife cut phase
- Appearance of chlorotic patches towards the base of the young leaves
- In acute cases disease shows distortion of stalk with external and internal cut like lesions and rotting of apical part of stalk.
- Under field conditions, the disease may develop many variations from the general symptoms, but the final result is usually a malformed or damaged top and stalk.
- The base of affected leaves is often narrower as compared to normal leaves.
- Knife cut symptoms of the disease were reported in varieties some varieties.

- The apical leaves may also show pronounced wrinkling and twisting depending upon the susceptibility of varieties and existing climatic conditions also malformed or damaged top and stalk due to this disease.

Pathogen: - ***Fusarium moniliformae***

- Asexual reproduction -Macro and micro conidia are produced.
- Micro conidia are hyaline, single celled and oval.
- Macro conidia are slightly sickle shaped, and two to five celled.
- The fungus produces the phytotoxin, fusaric acid, which is non-host specific.

6. **Gummosis**

Symptoms

- Leaves – longitudinal streaks or strips, strips are pale yellow later brown color changed.
- Canes- it are stunted with short internodes , bushy appearance
- Nodal region vascular system – dull yellow bacterial ooze comes out from the cut end of through cracks of the canes, vascular bundles are deep red colour

Pathogen: ***Xanthomonas campestris*** **pv** ***vasculorum***

- The bacterium is a short rod, 1.0-1.5x0.4-0.5μ, motile single polar flagellum, gram – ve, non- spore, non-capsule, and non-acid-fast.

6. Red stripe

- Chlorotic lesions carrying dark red stripes, several of them coalesce to cover large areas of the leaf blade and to cause the wilting and drying of the leaves.
- The growing tips are yellow and later reddish with dark brown stripes.rotting are comes from tip to downwards dark red discolouration of tissue.

Pathogen: ***Pseudomonas rubrilineans***

- Short rod 0.7-1.5x0.4-0.7μ, it is motile single polar flagellum, it is gram negative, non-acid , non-capsular , and produce small glistening, buff to yellow colonies on medium.

7. Sugarcane Mosaic

- Chlorotic stripe alternate with normal green in young leaf and leaf sheath
- Plant stunted and chlorotic

Pathogen: ***Potato Virus Y***

- Sugarcane mosaic virus is rod shaped, measuring 650-770 X 12-15μm. It belongs to Potato Virus Y group. In India atleast six strains, viz., A, B, C, D, E, and F have been identified. Strain B is the most common which produces a mild mottle of the leaf.

8. Grassy shoot

- Clumps stunted, thin with short internodes having aerial roots

- Leaves pale yellow to chlorotic thin and narrow
- Plants appear bushy – appears grass like
- Buds papery and abnormally elongated

Pathogen: ***Candidatus Phytoplasma***

- Phytoplasma is found in the sieve cells of infected plants. Two types of bodies are noticed, spherical bodies of 300-400 nm diameter and filamentous bodies of 30-53 mm diameter.

9. **Phanerogamic parasite :** ***Striga euphrasioides***

- Partial root parasite, growing up from the roots to form a leafy shoots.
- The parasite cans synthesis carbohydrates through the green chlorophyll pigments in the leaves but its other nutrients it depends on host root.
- It is usually controlled by pulling out the shoots before flowering and seed set.

Ex. No.4 **DISEASES OF MANGO AND SAPOTA**

Date

DISEASES OF MANGO

1. MALFORMATION

Symptoms

Bunchy top phase

- Formation of bunch of thickened small shootlets.
- Shootlets are short and stunted.
- Gives bunchy top appearance

Vegetative malformation

- Excessive vegetative branches. Swollen with short internodes.
- Seedlings give a bunchy top appearance.

Floral malformation

- Malformed head dries as black mass.
- Persist in the tree for long time.
- Primary axis and vegetative branches are transformed into vegetative branches shortened and resemble witches broom.
- The affected inflorescence are of three types viz., heavy , medium and light

Pathogen: ***Fusarium moniliforme* var. *subglutinans***

- The Pathogen produces microconidia, macroconidia and chlamydospores.
- Microconidia are 1 or 2 celled, oval, fusiform. Macroconidia are 2 or 3 celled, septate, falcate and tapered at the end.

2. POWDERY MILDEW

Symptoms

- Powdery growth covers the stalks of the panicle, flowers, tender fruits and leaves.
- Affected fruits and flowers fall prematurely.

Pathogen: *Oidium mangiferae*

- Mycelium is hyaline, branched, septate. It produces haustoria inside the epidermal cells.
- It also produces short conidiophore and conidia.
- Conidia are borne singly (or) rarely in chains.

3. ANTHRACNOSE:

Symptoms

- The varieties Neelam and Malgoa are highly susceptible
- Black or dark coloured circular spots on leaves with shot holes.
- Die back symptom on young twigs and inflorescence
- Flower stalk infected, flowers wither and shed. Tender fruits turn black and fall off.

- Black circular or irregular sunken spots on fruits

Pathogen: *Gloeosporium gloeosporiodes*

- The Pathogen produces acervuli which appear as pinkish dots.
- Conidia are borne on hyaline conidiophores.
- Conidia are straight (or) cylindrical (or) oval, hyaline with 2 oil drops and non-septate with round ends

4. DIE BACK

Symptoms

- Prevailing in abandoned gardens
- Dying of twigs from tip downwards
- Leaves turn brown and upward rolling. Leaves fall off
- Internal browning of wood tissue and cracks appear on branches which exude gum.
- Base of pedicel of fruit darkens. Circular black patch appears which turn fruit completely black. Pulp becomes brown and soft.

Pathogen: *Lasiodiplodia theobromae*

- Pycnidial fungi inside the pycnidia, conidiogenous cells produce hyaline thin walled pycnidiospores which become brown, thick walled, two celled with longitudinal striations.

5. SOOTY MOULD

Symptoms

- Black encrustation formed on flowers, leaves ,stem and fruit
- Mycelium superficial and lives on the sugary secretion of the sucking pests like hoppers, jassids, aphids and mealy bugs.
- Photosynthetic activity of plant is reduced

Pathogen: *Capnodium mangiferae*

- Fungus produces 5 types of conidia such as1. Torula 2. Trichothecium 3. Coniothecium 4. Brachysporium 5. Ascospores from Pseudothecia

6. GREY BLIGHT

Symptoms

- Brown spots develop at the margin and tip of the leaf lamina and distributed irregularly on the entire leaf.
- Black dots appear at the centre of the ashy grey spots represent the acervuli.

Pathogen: *Pestalotiopsis mangiferae*

- Conidia are 5-celled, clavate / fusiform. Top and bottom cells are hyaline and middle 3 cells are dark coloured.
- Appendages are seen at the top portion.

7. Red rust

Symptoms

- Spots are greenish grey in colour and velvety in texture with feathery margin.
- Later they turn reddish brown.
- Algal spots on fruits reduce the quality and marketability

Pathogen: *Cephaleuros virescens*

- The algae produce sporangia on sporangiophore.
- 5-8 sporangia are formed on each vesicle.
- Sporangia produce numerous quarter flagellate zoospores.

8. Bacterial leaf spot

Symptoms

- Leaf lesions consist of black, raised, angular areas, restricted by the veins and frequently surrounded by a yellow margin.
- Elongated stem cankers occur on the bark and can cause terminal dieback. Fruit lesions consist of individual or multiple star-shaped cracks, often appearing with anthracnose lesions in a tearstain pattern.
- The bacterial lesions do not expand as the fruit ripen.
- In young trees the disease can cause dieback of branches.

Pathogen: *Xanthomonas axonopodis pv. mangiferae*

- It is a gram negative, rod shaped bacterium with single polar flagellum.
- Commonly multiplied by binary fission

9. **GIANT MISTLETOE: Partial stem parasite – Loranthus** *(Dendrophthoe spp.)*

- The flowering plant parasitizes slender branches of the host tree by means of bulged haustoria.
- It derives nutrients and water from the host and makes the host branches to die.
- The severely attacked trees are weakened and their productivity is lowered.

DISEASES OF SAPOTA

1. Flat limb

Symptoms

- Branches of the affected trees become flat and twisted with severe bunching of leaves which become small, thin and yellow.
- The affected branches bear small, dry, hard and shrivelled fruits and these affected branches give rise to normal branches during summer months.

Pathogen: ***Botryodiplodia theobromae***

- The fungus produces pycnidia.
- Young conidia are hyaline thin walled and single celled.
- Matured conidia are dark brown in colour, 2 celled.

2. Sooty mould

Symptoms

- Black encrustation formed on flowers, leaves ,stem and fruit
- Mycelium superficial and lives on the sugary secretion of the sucking pests like hoppers, jassids, aphids and mealy bugs.
- Photosynthetic activity is reduced which results in reduced fruit set and fruit fall

Pathogen: *Capnodium mangiferae*

- Fungus produces 5 types of conidia such as 1. Torula 2. Trichothecium 3. Coniothecium 4. Brachysporium 5. Ascospores from Pseudothecia

3. Leaf spot

Symptoms

- Small circular pink to dark brown spots with whitish centre appear on leaves at the time of maturity
- Premature leaf fall resulting in yield reduction.
- Maximum incidence of the disease is observed in the months of October to December

Pathogen: ***Phaeophleospora indica***

- Sub epidermal dark walled cup shaped pycnidia which contains brown, verrucose, cylindrical conidiophores
- Conidia are cylindrical, brown smooth walled single to multi septate

4. Grey blight

- Numerous small reddish brown pecks on lamina
- Greyish centre with reddish margin

- In the centre black fruiting bodies seen

Pathogen: ***Pestalotiopsis versicolor***

- Conidia are 5-celled, clavate / fusiform.
- Top and bottom cells are hyaline and middle 3 cells are dark coloured with appendages

Ex.No:5 **DISEASES OF CITRUS AND GRAPEVINE**

Date:

DISEASES OF CITRUS

1. Foot rot/ Gummosis/ Leaf fall

Symptoms

- Sap oozing from small cracks in the infected bark, giving the tree a bleeding
- Profuse exudation of gum from the bark of the trunk
- The bark stays firm, dries, and eventually cracks and sloughs off appearance
- Lesions spread around the circumference of the trunk, slowly girdling the tree.
- Decline may occur rapidly within a year

Pathogen: ***Phytophthora palmivora***

- Hyaline coenocytic mycelium.
- Sporangiophores are slender sympodially branched which bears elliptical non-papillate sporangia with slight apical thickening with kidney shaped, biflagellate zoospores.
- Sexual spore is oospore

2. Scab / Verucosis

Symptoms

- Sour orange, rough lemon and tangerine are highly susceptible

On Twigs, petioles or newly emerging shoot apices

- Tangerine cultivar of citrus is highly susceptible.
- Light brown, raised, circular scabs appear on young stems or green twigs.

On Leaves

- Light brown pustules or scabs develop on young leaves, and are sometimes visible on both upper and lower surfaces. Distortion and malformation of leaves.

On Fruits

- Light brown, raised, rounded, warty scabs appear on the rind of young fruits.
- Scab will be pink to light brown during disease initiation and from grey to black later in the season.

Pathogen: ***Elsinoe fawcettii***

- **Asexual stage:** *Sphaceloma fawcettii*
- Conidia are produced on acervuli on the surface of lesions on leaves or fruit with larger, spindle-shaped hyaline single celled conidia with minute droplets/oil globules at the end.
- **Sexual stage:** *Elsinoe fawcettii*
- Produce pseudothecium with ascus and ascospores which are hyaline to yellow, 1 to 3 septate and elliptical.

3. **Anthracnose / Die back**

Symptoms

- Dark brown circular spots with grey brown centre and acervuli are arranged in concentric circle on leaf lamina
- Branches wither from tip to downwards.
- Acervuli appear as black dots on dead twigs and fruits.
- Initially reddish brown spots develop on fruits and later turn to brown colour circular and sunken spots.

Pathogen: ***Gloeosporium gloeosporioides***

- Hyaline, septate and branched conidiophore on which cylindrical, single celled, hyaline and thin walled conidia with large number of oil globules are produced.

4. **Powdery mildew**

Symptoms

- White powdery patches of fungal growth on upper surface of young leaf.
- In severe cases covers the entire leaf, petiole and stem.
- Yellowing, crinkling and defoliation of leaf
- Young fruits are affected and drop off.

Pathogen: *Acremonium (Oidium) tingitaninum*

- Mycelium is ectophytic, hyaline and branched
- Hyaline club shaped conidiophore with chain of barrel shaped conidia arranged in basipetal succession.
- Sexual fruiting body is chasmothecium which bears asci and ascospores.

5. **Sooty mould**

Symptoms

- Black encrustation formed on flowers, leaves ,stem and fruit
- Mycelium superficial and lives on the sugary secretion of the sucking pests lik hoppers, jassids, aphids and mealy bugs.
- Photosynthetic ability reduced which results in reduced fruit set and fruit fall

Pathogen: *Capnodium citri*

- The fungus produces 5 types of conidia such as 1. Torula 2. Trichothecium 3. Coniothecium 4. Brachysporium 5. Ascospores from Pseudothecia

6. **Canker**

Symptoms

Lime is highly susceptible while sweet orange is highly resistant

Leaf canker

- Circular brown colour corky cankerous growth with yellow halo on both the surface of the leaves

Stem canker

- Irregular corky lesions appear on the petiole, twigs and young stem leads to die back symptom
- Girdling of stem and partial or complete drying of seedlings

Fruit canker

- Corky cankerous out growth seen on the fruits without yellow halo and reduces market value.

Pathogen: *Xanthomonas axonopodis* pv.*citri*

- Gram negative rod shaped bacteria , motile with single polar flagellum

7. Citrus Greening /Huanglongbing (HLB)

Symptoms

- Stunting of leaves, sparse foliation, twig die back, green fruits with a yellow patches on the rind
- Chlorosis of leaves resemble to Zn deficiency
- Twigs become upright position with smaller leaves
- Fruits are small lopsided with curved columella
- Sun exposed side of the fruits developed full orange colour, other side remain dull olive green in colour .Fruits low in juice with high soluble solid and acidity
- Seeds are poorly developed, dark coloured and aborted

Pathogen: ***Candidatus Liberibacter asiaticus***

- It is a phloem limited fastidious bacterium transmitted by Asian citrus psyllid, *Diaphorina citri*

8. **TRISTEZA /QUICK DECLINE**

Symptoms

- Vein flecking in large number on leaves,
- Stunting of trees, stem pitting, root decay, dieback of twigs,
- Yield is reduced and fruits are very small.

Pathogen: Citrus tristeza virus

- Flexuous thread like rod shaped RNA virus and located in phloem vessels of the root stock.
- Vector: Black citrus aphid-*Toxoptera citricidus / T.auranti*

5. **GIANT MISTLETOE:** ***Loranthus*** *(Dendrophthoe spp.)*

- The flowering plant parasitizes slender branches of the host tree by means of bulged haustoria.
- It derives nutrients and water from the host and makes the host branches to die.
- The severely attacked trees are weakened and their productivity is lowered.

DISEASES OF GRAPES

1. Downy mildew

Symptoms

- Small translucent, pale yellow oily spots on upper surface and downy growth on the corresponding lower surface.
- Severe infection leads to development of necrotic lesions and finally resulting in defoliation
- Infected leaves, shoots and tendrils are covered with whitish growth. Flowers and berries affected
- Affected berries leathery and wrinkled and become mummified without cracking.

Pathogen: ***Plasmopara viticola***

- Hyphae are coenocytic, thin walled and hyaline.
- Sporangiophores produced in clusters branched at right angles.
- At the apex of each branch, 2-3 sterigmata arises which borne thin walled, lemon shaped papillate sporangia containing zoospores.
- Zoospores are reniform or kidney shaped, biflagellate with tinsel and whiplash type flagella.
- Sexual or resting spores are called oospores which are brown and thick walled.

2. Powdery mildew

Symptoms

- White powdery patches on the upper surface of the leaf. Leaves discoloured and malformed.
- Powdery growth on the stem, tendrils, flowers, young fruit bunches and berries.
- Stem turns grey and finally dark
- Flowers wither and dry up
- Powdery growth on the berries leads to cracking of berries

Pathogen: *Erysiphe* (*Uncinula) necator*

- Mycelium ectophytic, slender, branched and septate.
- Conidiophores are short, erect and bear a chain of 3 or 4 oval shaped conidia.
- Chasmothecia are black and contain 8 to 12 ovoid asci. Each ascus contains 4 – 6 oval shaped ascospores.

3. Anthracnose / Birds Eye Spot

- Small, circular or irregular dark brown spots with shot hole
- Red spots on berry – circular, sunken and ashy grey – surrounded by dark margin (like birds eye)
- Girdling of the stem

Pathogen: *Elsinoe ampelina*

- Asexual stage: Conidia are hyaline, single celled, oblong or ovoid.
- Sexual stage: Pseudothecia with several asci. Each ascus contains 8 ascospores with 4 celled.

4. RUST:

Symptoms

- Heteroecious rust and the spermogonial and aecial infection appeared on the alternate host, *Meliosma myriantha*.
- Yellowish to brownish rusty pustules appear on the lower surface of the leaves which contains yellowish-orange masses of uredospores.
- The telia are crust-like and orange-brown initially, but become dark brown or almost black.
- Heavy infection causes early senescence and dropping of the leaves.

Pathogen: ***Phakopsora euvitis***

- It is an obligate parasite.
- Uredosori are minute, subepidermical, becoming erumpent, surrounded by cylindrical paraphyses and Urediniospores are yellow, elliptical and pedicellate.
- Telia are subepidermical and teliospores irregularly arranged in 3-4 layers, oblong to cylindrical in shape.

5. Fan leaf

Symptoms

- Virus diseases Vines become stunted or less vigorous than the normal.
- Leaves are variously and severely distorted, asymmetrical, cupped and puckered and exhibit acute dentations. Chlorotic mottling may sometimes accompany foliar deformations.
- Canes are also malformed, showing abnormal branching with shortened internodes.
- Bunches are reduced in number and size, ripen irregularly and have shot berries and poor berry setting.

Pathogen: Grapevine fan leaf NEPO virus (GFLV)

- It is an icosahedral shaped RNA virus
- Vector: Dagger Nematode -*Xiphinema index*

Ex.No:6 **DISEASES OF JACK FRUIT, PINE APPLE, BER, APPLE, PEACH, PLUM, STRAWBERRY**

Date:

DISEASES OF JACK FRUIT

1. Pink disease

Symptoms

- Affects young branches and pinkish out growth are seen on the surface
- Further penetrates bark and grows inside and subsequently enters cortex
- Due to interuption of flow nutrients, leaves become yellow
- Leaf crinckle and shedds and twigs get dried. Pink encrustation is seen on the lower shaded area.

Pathogen: ***Pellicularia salmonicolor***

- The mycelium of fungus in the culture appear as hyaline, septate, branched, with rapidly spreading hyphae and produce pink-salmon colour when exposed to shaded natural light.
- The hyphae consist of thickening or swellings at some places called dolipore septa along with prominent clamp connection.
- Conidia of Corticium salmonicolor appeared as small hyaline oval or irregular in shape

2. Rhizopus fruit rot

Symptoms

- In young fruit rots begins in the stalk and covered by the mycelium.
- The fruits are mummified and drop down.

Pathogen: ***Rhizopus atrocarpi***

- Coloured, coenocytic mycelium with rhizoids and tuft of sporangiophore with sporangia.
- Aplanospores are sticky in nature.

DISEASES OF PINEAPPLE

1.Heart rot

Symptoms

- Yellowing of leaves which later in to above brown coloured, yellowish white area at base of leaves with brown margin
- Fruit development is arrested and entire plant wilts from the tip downward
- The fruits exhibits spongy texture
- When the plant is pulled out the roots appear dark and in the process of decaying.

Pathogen: *Phytophthora parasitica / P. cinnamomi*

- Hyaline coenocytic mycelium.
- Sporangiophores are slender sympodially branched which bears elliptical non-papillate sporangia with slight apical thickening with kidney shaped, biflagellate zoospores.
- Sexual spore is oospore.

DISEASES OF BER

1. Powdery mildew

Symptoms

- The disease appears by the end of October and prevails up to April.
- The disease first appears on young leaves in the form of white floury patches and later spreads to the young shoots and developing fruits.
- With the passage of time, the infected area becomes slightly raised and rough.
- The in-fected fruit often becomes malformed and may shed from the tree.

Pathogen: *Oidium erysiphoides* f. sp. *zizyphi*

- Hyaline club shaped conidiophore with chain of barrel shaped conidia arranged in basipetal succession.
- Sexual fruiting body chasmothecium which bears asci and ascospores.

2. Black leaf spot

Symptoms:

- Sooty tuft like circular to irregular black spot de-velop on leaf surface.
- When infection ad-vances, it covers a large area on the lower sur-face of the leaves and corresponding upper surface shows brownish discoloration

Pathogen: *Isariopsis indica* var. *zizyphi*

- Fungus produces synnemata consists of loose conidiophores which bears dark to ale one or two celled often curved conidia at the top.

3. Anthracnose

Symptoms:

- Irregular, rough or corky reddish brown spots with yellowish margin, having the size of 2 to 3 mm in diameter.
- The spots generally appear on the upper surface of leaves and are not restricted by veins.
- Initially these spots were isolated but at later stage they may coalesced to form large patches on the infected leaves.
- On the fruit surface symptoms were small, circular to roughly circular; brown to black colored spots with depressed sporulating zone at the center.
- Size of spots quickly enlarges during color change of fruit peel from green to yellow and on each fruit usually 3-4 spots were recorded.

Pathogen: *Colletotrichum gloeosporioides*

- Mycelium septate.
- Conidiophore bears the conidia which are falcate, hyaline unicellular with narrow

ends. Acervuli and setae present

4. Rust

Symptoms

- The disease first appeared on the lower surface of leaves as small, irregular, reddish brown uredo-pustules which later advances to cover the whole surface of leaves.
- The infected leaves finally shed off from the tree
- Autocious rust.

Pathogen: ***Phakopsora zizyphi-vulgaris***

- Uredosori with peripheral incurved Paraphyses.
- Uredia hypophyllous, scattered, reddish brown, subepidermal, erumpent, paraphysate, paraphyses invariably marginal incurved, thickened
- Urediospores borne on long stalks, obovate or elliptic, narrowed towards the base, echinulate above, the lower one-third smooth, germpores 2-3, cinnamon brown.

DISEASES OF APPLE

1. Scab

Symptoms

- Symptom appears on leaves and fruits.
- On lower side of the leaf lesion appear as olivaceous spots which turn dark brown to black and become velvety.
- On young foliage, the spots have a radiating appearance with a feathery edge.
- On older leaves the lesions are more definite in outline.
- The lesion may form a convex surface with corresponding concave area on the opposite side.
- In severe infection leaf blade curved, dwarfed and distorted.
- Fruits show small, rough, black circular lesions.
- The centre of the spots become corky and on mature fruits, yellow halo is seen around the lesions.

Pathogen: *Venturia inaequalis*

- Septate, branched and coloured mycelium.
- Conidiophores are brown, rarely septate.
- Conidia are generally unicellular / bicellular, truncate at base and pointed at tip and brown coloured.
- Ascocarp is Pseudothecium which consists of numerous asci with boat shaped bicelled ascospores with unequal in size.

2. Powdery mildew

Symptom

- Small patches of white powdery growth appear on upper side of leaves.
- In severe case the symptom appear on both the sides.
- Twigs are also infected. Affected leaves fall off in severe infection.
- Fruit buds are also affected and deformed or remain small.

Pathogen: *Podosphaera leucotricha*

- Ectophytic, with saccate haustoria.
- Conidiophores arise on leaves and young shoots bears long chain of hyaline, oval shaped single celled conidia with fibrosin bodies.
- Chasmothecium consists of ascus which in turn possesses ascospores.

3. **Soft rot**

Symptom

- Young spots starts from stem end of the fruit as light brown watery rot. As the fruit ripens area of the rotting increases,
- Skin becomes wrinkled.
- A peculiar musty odour is emitted
- Under humid condition a bluish green sporulating growth appears.
- Infection take place by wounds in the skin caused by insects and during handing in storage and transport

Pathogen: ***Penicillium expansum***

- Branched conidiophore bears green or bluish green mass of elliptical conidia in chain.
- Primary and secondary spread through wind borne conidia

4. **Bitter rot –** ***Glomerella cingulata***

Symptom

- Faint, light brown discolouration beneath the skin develops.
- The discolouration expands in a cone shape.
- The circular, rough lesions become depressed. The lesions increased and cover entire areas of fruits.
- Tiny black dots appear beneath the cuticle which gives rise to acervuli
- Pink masses of spores are found arranged in defined rings.

5. **Fire blight**

Symptom

- The initial symptom usually occurs on leaves, which become water soaked, then shrivel turn brownish to black in colour and fall or remain hanging in tree.
- The symptom spread to twigs. Terminal twigs wilt from tip to downward and forming a very typical "shepherd's crook" symptom
- Fruits become water soaked, turn brown, shrivel and finally become black.
- Oozing may be seen in the affected area.

Pathogen: ***Erwinia amylovora***

- Rod shaped, motile, peritrichous bacteria.
- Each bacterial cell is enclosed in a capsule.
- Bacterium from infected plant parts served as primary inoculum and secondary spread is through irrigation water, insects and rain splash.

DISEASES OF PEACH

1. Peach leaf curl

Symptom

- It attacks the leaves, causing curling and blister formation.
- The leaves start turning yellowish or reddish and fall off prematurely.
- The infected portion develops a pink or reddish bronze colour.
- Growth of the tree is affected with a reduction of yield.

Pathogen: ***Taphrina deformans***

- Intercellular mycelium devoid of ascocarp.
- Naked asci are produced individually and bear eight ascospores.
- Ascospores undergo budding division before released from Ascus.
- Ascospores as well as budded conidia from ascospores served as inoculum

2. Powdery mildew

Symptoms

- Small superficial white powdery mass on leaves appear.
- All the parts like leaves, twigs and fruits are infected with this fungus.
- Fruits may turn pinkish and finally dark brown in colour.

Pathogen: ***Sphaerotheca pannosa***

- Ectophytic, with saccate haustoria.
- Conidiophores arise on leaves and young shoots bears long chain of hyaline, oval shaped single celled conidia with fibrosin bodies.
- Chasmothecium consists of ascus which in turn possesses ascospores.
- Primary spread is through air borne ascospores and secondary spread is through air borne conidia

1. **Pocket plum or Bladder plum gall**

Symptoms

- Gall appears on the developing fruit form elongated, flattened, hollow, stone-less
- The surface of the gall becomes corrugate and coated with the fungus, showing as a white bloom of ascospores
- The totally inedible fruits shrivel and most fall

Pathogen: *Taphrina pruni*

- Intercellular mycelium devoid of ascocarp.
- Naked asci are produced individually and bear eight ascospores.
- Ascospores undergo budding division before released from Ascus.
- Ascospores as well as budded conidia from ascospores served as inoculum

DISEASES OF STRAWBERRY

1. Leaf Spot

Symptoms

- Symptoms of leaf spot first appear as circular, deep purple spots on the upper leaf surface.
- These spots enlarge and the centers turn grayish to white on older leaves and light brown on young leaves.
- A definite reddish purple to rusty brown border surrounds the spots.
- On fruit, superficial black spots may form under moist weather conditions. The spots form on ripe berries around groups of seeds.
- The spots are about ¼ inch in diameter, and there are usually only one or two spots per fruit. However, some fruits may be more severely infected.

Pathogen: *Mycosphaerella fragariae*

- The fungus overwinters as sclerotia in the soil
- The fungus infects the plant and produces more spores in spots on the upper and lower leaf surface that spread the disease during early summer
- Conidia are produced on clusters of short conidiophores on underside of the diseased area
- Perithecia are formed in autumn at the edge of the leaf spot where the fungus winters
- New conidia are produced in spring with most infection taking place through stomata

2. Leaf Scorch

Symptoms

- Leaf scorch consists of numerous small, irregular, purplish spots or "blotches" that develop on the upper surface of leaves.
- The centers of the blotches become brownish.
- Blotches may coalesce until they nearly cover the leaflet, which then appears purplish to reddish to brown.

Pathogen: *Diplocarpon earliana*

- Conidia in abundance, often with conidiophores attached. T
- hese conidiophores are at most 3 to l0 μ long and 3 to 4μ in diameter. The conidia are hyaline, asymmetri cally two-celled with the upper cell larger and beaked, curved, constricted at the septa, guttulate
- The asci are fasciculate, oblong, taper bluntly at thickened apex, the ascopores and hyaline, elliptical and two celled.

3. Leaf Blight

Symptoms

- One to several circular reddish-purple spots on a leaflet.
- Spots enlarge to V-shaped lesions with a light brown inner zone and dark brown outer zone.
- Lesions follow major veins progressing inward. The whole leaflet may turn brown.
- In severe cases, stolons, fruit trusses and petioles may become infected which may girdle and kill the stem.

Pathogen: *Phomopsis obscurans*

- The fungus overwinters as mycelium or fruiting structures on the old leaves that remain attached to the plant.
- The pycnidia of *P. obscurans* are produced on the upper surface of leaves and are immersed, black, globose and have short protruding ostiolar necks.
- Conidia are hyaline, unicellular and fusiform.
- Each conidium has two to three guttulae with one guttula at each end of the spore. The conidia are borne on hyaline conidiophores that are vertically to irregularly branched and measure up to 85 µm long.
- Conidia are exuded in mass as tendrils or globules and usually have a pale amber color

4. Angular leaf spot

Symptoms:

- On leaves, 1-4 mm, angular, shiny, water-soaked spots appear surrounded by the smallest veins.
- In the early stage the spots are only visible on the lower surface and appear translucent against the light.
- They enlarge, coalesce and after about 2 weeks are also visible on the upper surface as water-soaked, angular spots, which become reddish-brown in colour.
- They have a shiny appearance and are usually covered by bacterial exudate which when dry turns brown and appears as gum-like scales.
- Spots coalesce more frequently along the primary and secondary veins.
- The dead tissues tear and break off, and the diseased leaf may assume a ragged appearance.

Pathogen: *Xanthomonas fragariae*

- *Xanthomonas fragariae* is a gram negative, aerobic, rod-shaped
- Colonies of *X. fragariae* usually are mucoid, convex, and yellow when grown on yeast dextrose calcium carbonate (YDC) media or sucrose peptone agar (SPA).
- All members of the genus *Xanthomonas* are catalase positive and oxidase negative

Ex.No.7. **DISEASES OF CUCURBITS**

Date:

1. Fusarium wilt of watermelonSymptoms:

- On young seedlings, a hypocotyl rot and damping-off may occur.
- In older plants, there is marginal yellowing progressing to a general yellowing of the older leaves, and wilting of one or more runners.
- In some cases, sudden collapse occurs without any yellowing of the foliage. On stems near the crown of the plant, a linear, necrotic lesion may develop, extending up the plant and usually on one side of the vine.
- One runner on a plant may wilt and collapse, with the rest of the runners remaining healthy. A gummy, red exudate may ooze from these lesions
- Vascular discoloration should be evident and is very diagnostic
- Mature plants often wilt severely (collapse) late in the season because of the fruit load stress.

Pathogen: ***Fusarium oxysporum f.sp. niveum***

- Produces micro conidia, macro conidia, and chlamydospores
- Primary spread is through soil borne chlamydospores and secondary spread is through water borne conidia

2. Root rot

Symptoms

- Yellowing of leaves, stunted, poor fruit set
- Root affected – sunken darkened lesions on fleshy roots
- Crown girdled

Pathogen: ***Pythium aphanidermatum , Phytophthora sp.***

- *Pythium* produces coenocytic mycelium with sporangiophore bearing irregular shaped sporangia
- The sporangia put forth vesicle which bears the zoospores
- *Phytophthora* produces coenocytic mycelium with sporangiphore bearing papillate sporangia which bears the zoospores.

3. Anthracnose

Symptoms

- On leaves: small yellow spots, turn brown
- Attack stem and fruit
- On stem, sunken lesions are formed
- On fruits: circular, black, sunken spot. Infected portion bears acervuli.

Pathogen: ***Colletotrichum lagenarium***

- Mycelium hyaline , septate and branched
- Conidiophore bears the conidia which are falcate, hyaline unicellular with narrow ends.

- Acervuli and setae present
- Primary spread is through ascospores from plant debris and secondary spread is through wind borne conidia

4. Downy mildew

Symptoms

- Downy growth on the lower surface of leaf.
- Small purplish brown spots appear initially on the under surface of leaves

Pathogen: ***Pseudoperonospora cubensis***

- The sporangiophores are dichotomously branched at acute angles and taper into gracefully curved pointed tips on which sporangia are borne
- Primary spread is through soil borne oospores and secondary spread is through zoospores

5. Powdery mildew

Symptoms

- Upper surface small white or greyish superficial spots later entire leaves covered by fungal growth.
- Defoliation occurs.
- Fruits are small and yield reduced.

Pathogen: ***Golovinomyces cichoracearum***

- Conidia are single celled, hyaline barrel-shaped and in long chains.
- Chasmothecium are globose and dark with hyaline to dark brown myceloid appendages.
- Asci are pedicellate, and ovate. Ascospores are single celled, hyaline oval to sub cylindrical.
- Primary spread is through ascospores from infected plant debris and secondary spread is through wind borne conidia

6. Bacterial wilt

Symptoms

- Leaves become dull green and wilts rapidly. Finally plant collapse.
- On fruits: Water soaked tissue appear, glistening exudations appear

Pathogen: *Erwinia tracheiphila*

- Gram negative bacteria with peritrichous flagella

Vector: Striped Cucumber beetle: *Acalymma vittatum;* Spotted cucumber beetle: *Diabrotica undecimpunctata howardi*

7. Cucumber mosaic

Symptoms

- Susceptible stage: 6 weeks old crop
- Yellow mottling and leaf distortion
- Plant dwarfed – inter nodes shortened

- Gives a bushy growth, leaves close to the ground in a rosette like clump
- Fruits become mottled and slowly spread to entire fruit. Fruit becomes light yellowish green, intermingled with spots of a much darker green colour.
- Produce distorted fruit with irregular green areas and later becomes white which is called as white pickle.

Pathogen: **Cucumber mosaic virus**

- CMV is the type species of the genus *Cucumovirus* in the family *Bromoviridae*. It is a RNA virus
- Transmitted by aphids species *Myzus persicae* and *Aphis gossypii*

Ex.No.8. **DISEASES OF POTATO, PEAS, BEET ROOT, RADISH**

Date:

DISEASES OF POTATO

1. Black scurf and stem canker

Symptoms

Sprout injury:

- Dark brown lesion on cortical and vascular tissue. Sprout killed

Stem canker and wilt:

- Reddish brown lesions or cankers on stem resulting in girdling .Disease spreads to petiole and leaflets.
- Xylem vessels affected resulting in stem rot and wilting
- White crust around the haulm at ground level

Black scurf:

- Chocolate coloured specks on the surface of the tubers
- Black sclerotia formed on tubers
- Russeting of tubers
- Browning of internal tissues causing hard dry rot

Pathogen: *Rhizoctonia solani*

- Septate mycelium with a constriction at branch.
- Sclerotia are irregular brown to black.
- Perfect stage: *Thanatephorus cucumeris. B*asidia with basidiospores are produced
- Primary spread is through the infected tubers and secondary spread is through sclerotia

4. Wart / Black wart

Symptoms

- Small white soft, pulpy wart on the eyes. resembles cauliflower
- Wart later turns black
- In severe cases during wet season the auxillary bud or the leaf is transformed into greenish yellow outgrowth resembling cocks comb.

Pathogen: *Synchytrium endobioticum*

- Obligate parasite, endobiotic (inside the cell) produces zoospores which develops into prosorus
- Primary spread is through resting spores present in soil and infected tubers, while secondary spread is through zoozpores

3. Early blight Leaf symptom:

- Brown spots becomes angular with or without concentric rings
- Spots enlarge to form necrotic areas
- Leaves dry and hangs along the stem

Tuber symptom

- Dark brown circular or irregular slightly sunken spot .
- Internal tissues become brown and corky.

Pathogen: ***Alternaria solani***

- Hyphae septate, branched, dark coloured
- Conidiophores are short and dark in colour,
- Conidia are beaked, obclavate, formed singly, olive brown, muriform with both horizontal and vertical septation.
- Primary spread is through dormant mycelium in plant debris and Tuber, while secondary spread is through conidia

4. Late blight:

Leaf symptom

- Brownish to purplish black water soaked lesions on upper surface
- White mildew growth appears on lower surface.
- Spreads from leaf to petiole and then to stem
- Stem breaks and plant topples.

Tuber symptom

- Purplish discolouration of the skin followed by dry rot

Pathogen: ***Phytophthora infestans***

- *Phytophthora* produces coenocytic mycelium with sporangiophore bearing papillate sporangia which bears the zoospores.
- Primary spread is through oospore, dormant mycelium in plant debris and Tuber, while, secondary spread is through zoospores produced in sporangia

5. Soft rot:

Symptoms

- Water soaked areas around the lenticels
- Internal tissue decay and becomes brown and later black
- Affected tissues become soft and a reddish or black demarcation seen between healthy and affected tissues.
- Affected tissues become slimy and emit sulphurous odour.

Pathogen: ***Pectobacterium carotovorum*** **pv** ***carotovorum***

- Gram negative bacteria with peritrichous flagella

- Primary spread is through soil borne bacterium and bacteria in plant debris and Tuber, while secondary spread is through water born bacteria

6. Common scab:

Symptoms

- Rough, corky lesions, which may range from small and raised to deeply pitted.
- Initially, infections appear as small tan to reddish-brown spots on the tuber surface.
- Pitted scab can be as deep as one half inch into the tuber.
- Tubers with russetted scab can have large areas superficially covered with corky tissue.

Pathogen: *Streptomyces scabies*

- Streptomyces scabies is filamentous, gram positive bacteria spore and toxin producing bacteria.
- The toxin that causes the common scab symptoms is called thaxtomin.
- It disrupts the development of cell walls and results in scab lesions.
- Primary spread is through soil borne bacteria and infected plant debris while, secondary spread is through water borne bacteria

7. Mild mosaic/ mosaic/ Latent mosaic: Potato virus X

- Interveinal mottling with slight dwarfing or with deformed leaves
- Plants bushy and pale
- Mainly transmitted by tubers and mechanically through zoospores of Synchytrium endobioticum

8. Severe mosaic/ Vein banding: Potato Virus Y

- Leaf crinkle, roll upwards, form cup like structure. Plant stunted, and gives rosette appearance.
- Mottling of interveinal and veinal areas.
- Chlorotic streaks become necrotic and kill leaf. Streaks on stem.
- Transmission: Through infected tuber, Aphid (*Myzus persicae*) and mechanical means

9. Leaf roll:Potato leaf roll virus

- Tip and margins of leaves roll upwards
- Midrib takes the shape of spoon and later into funnel
- Leaflets brittle ,become yellow and then brown
- Necrosis of phloem
- Transmission: By Green peach aphid : *Myzus persicae* and infected tubers

DISEASES OF PEAS

1. Wilt

- Yellowing and drooping of leaves
- Stunting of plants
- Brown to black discolouration of xylem

Pathogen: *Fusarium oxysporum* f.sp. *pisi*

- Fungus has hyaline , septate , branched mycelia
- Produces micro conidia, macro conidia, and chlamydospores

2. Anthracnose

Symptoms

- Brown irregular spots with light centre and dark margin on the leaf and stem
- Brown circular suncken spots on the pods leads to pod rot
- Seeds become discoloured and shriveled

Pathogen: *Colletotrichum pisi*

- Pathogen produces conidia single celled; hyaline slightly curved with oil globule. Asexual fruiting body is acervuli.
- Primary spread is through dormant mycelium and ascospores from infected debris and secondary spread is through wind borne conidia

3. Rust

Symptoms

- Yellow spots having aecia in round or elongated clusters
- Pustules develop which are powdery and orange brown in appearance
- Drying of leaves

Pathogen: *Uromyces fabae*

- Uredospores: Single celled, brown coloured with echinulations. Teliospores: Single celled, brown with thickened apex
- Primary spread through teliospores and secondary spread through uredospores

4. Powdery mildew

Symptoms

- White powdery patches on the upper surface of the leaves.
- Drying of leaves
- This disease can delay the maturity
- Affect the flavor of the processed peas

Pathogen: *Erysiphe polygoni*

- Septate mycelium producing oidium type of conidia and conidiophores.
- Sexual fruiting body: Chasmothecium with many asci and ascospores

DISEASES OF BEET ROOT

1. Leaf Spot

Symptoms

- Numerous small circular spots appear on the leaf surface. The spots increase in size, becoming brownish or purplish in color.
- Individual spots are usually circular but several may coalesce into larger areas of dead tissue. The spots dry up giving a shot-hole appearance to the leaves.
- In case of severe infection spots cover the entire leaf surface resulting in pre-mature death and dropping of the leaves.
- As leaves die, the crown becomes cone-shaped with a rosette of dead leaves at the base.
- Defoliation occurs throughout the growing season resulting in reduction in root size and yield. Older leaves are mostly affected.

Pathogen: *Cercospora beticola*

- Conidia (spores) are needle-shaped (2-3 x 36-107 µm), colorless, and have several cross-walls (septations).
- Conidial morphology varies greatly with environmental conditions.
- Host plants include many weed species such as lambsquarters, pigweed, mallow, and bindweed.
- Economic hosts include tablebeet, sugar beet, Swiss chard, spinach, and most wild *Beta* species.

2. Downy Mildew

Symptoms

- Appear as irregular greasy greyish areas on the leaves. Under moist conditions, these areas expand rapidly and a white powdery growth appears on the lower surface of the affected leaves.
- Affected leaf dries and shrivels quickly. Flower shoots on infected plants become stunted and distorted.
- The entire inflorescence has a compact appearance and excessive leaf development may give an appearance witches broom.

Pathogen: *Perenospora schachtti*

- The fungus survives on the crop residues in the soil and is also carried by the seed.
- Mycelium coenocytic and intercellular with finger-like branched haustoria in the host cells.
- sporangiophores branching obscurely dichotomous tapering to a blunt point, angle of branching a right angle or less.
- Sporangia are ellipsoid, pale brown to violet and sexual spores are Oospores

3. Bacterial blight

Symptoms

- The infected leaves show irregular to circular shaped spots with tan to dark brown centers and dark black borders.
- In some instance symptoms also appear on the edges of the leaves which initially may appear water-soaked and later turn yellow and then necrotic.
- These spots may join together between the veins an the dried area falls off, which gives a ragged appearance

Pathogen: ***Pseudomonas syringae pv. aptata***

- The bacteria spread mainly by splashing rainfall, mechanical and insect injuries.
- The pathogen also infects other crops like bean, eggplant, lettuce, and pepper.

4. Mosaic

Symptoms

- Appear as conspicuous mottling with chlorotic, zonate ring spots on the leaf surface.
- When these ring spots develop their center are usually green.
- Virus infected plants remain stunted and may lose some leaves.

Pathogen:

- Spinach mosaic virus, sugarbeet mosaic virus (BtMV). It is a *Potyvirus* in the family *Potyviridae*.
- Vector(s) are *Myzus persicae*, *Aphis fabae*
- Virus is transmitted in a non-persistent manner.

5. Curly-top

- External symptoms of curly top virus infection may appear in leaves, stems, flowers, fruits, or roots of infected plants.
- Generally, mottling is absent, but infected plant parts may become distorted through curling, twisting, rolling, stunting, etc.
- Leaves become thickened and leathery
- Some of the most pronounced symptoms resulting from curly top virus attacks are internal and non-observable with the unaided eye.
- Such internal symptoms consist of death of the food conducting vessels, as well as of extreme variations from the normal in numbers and sizes of cells composing the plant tissues

Pathogen: ***Beet curly top virus (BCTV)***

- Caused by *Beet curly top virus (BCTV), Beet severe curly top virus (BSCTV, Beet mild curly top virus (BMCTV)*
- Transmitted by beet leaf hoppers *Circulifer tenellus*.

6. **Beet Yellows**

Symptoms:

- Yellow spots on the young leaves in the initial stages of infection.
- As the disease progresses, the leaves exhibit irregular yellow patches alternating with normal green colour of the leaves.
- The older leaves of infected plants become chlorotic, noticeably thickened, leathery and brittle.
- The foliage becomes abnormally red or yellow and often dies.

Pathogen: *Beet Western Yellows Virus (BWYV)*

- The virus is transmitted by aphids (green peach aphids and black bean aphids). It has an extensive host range

DIESEASES OF RADISH

1. Alternaria Blight

Symptoms

- The pathogen affects leaves, stem, pods and seeds.
- Symptoms of the disease first appear on the leaves of seed stem in the form of small, yellowish, slightly raised lesions.
- Lesions appear later on the stems and seed pods.
- Infection spreads rapidly during rainy weather, and the entire pod may be so infected that the styler end becomes black and shrivelled.
- The fungus penetrates in pod tissues, ultimately infecting the seeds. The infected seed fails to germinate.

Pathogen: ***Alternaria raphani***

- Conidia are light brown to medium brown in colour, smooth or minutely rough, sometimes verruculose, beakless and apically bluntly conical when juvenile, many have a long beak at maturity, the transition from spore body to beak is gradually tapering;
- conidium body 40-120 x 12-20 f-L111 on host, with 5- 14 transverse septa and several longitudinal or oblique septa; the beak filifonn, colourless or pale, septate, often once branched (bifurcate)

2. Whit e Rust

Sympto ms

- Disease attacks the leaves and flowering shoots.
- Affected flowering shoots get deformed and bear only malformed flowers.
- White powdery substance in patches is observed on the under surface of the leaves.

Pathogen: ***Albugo candida***

- When liberated, the sporangia inside the pustules are spread by wind, rain, and insects.
- After landing on a susceptible plant, each sporangium gives rise to about six zoospores which, under suitable conditions of moisture and light, form germ tubes which invade the plant's tissues.
- Zoospores are naked (wall-less), kidney-shaped and bi-flagellate. Both flagella are inserted laterally.
- Thick-walled sexual spores, called oospores are produced which germinate, producing either vesicles inside the plant tissue, exit tubes with vesicles at the tip, or germ tubes.

3. Downy mildew

Symptoms

- The disease is characterized by the appearance of the purplish brown spots on the under surface of the leaves.
- These spots may remain small or enlarge considerably.
- The upper surface of the leaf above the lesion is tan to yellow.

- Downy growth usually appears on the under surface of these lesions.

Pathogen: *Peronospora parasitica*

- Mycelia are intercellular in host tissues and no intracellular hyphae are observed; the pathogen entering leaf cells forming haustoria.
- Under humid conditions, erect, dichotomously-branched conidiophores are formed. These are generally about 350 µm long, bearing sub-elliptical sporangia 17–22×14–15 µm, and emerge through stomata on the lower surfaces of infected leaves.
- Oospores may be found in infected leaves, sepals, flower buds and stems.

4. Black rot

Symptoms

- It effects almost all the cruciferous plants all over the world. It is a seed-borne disease.
- The plant may be affected at any time during its growth from the youngest seedling until it matures.
- On young seedlings, the cotylcdons are affected at the margins which show blackening and such cotyledons die.
- Later, infection of leaves occurs through water pores at the margins. The infected tissues I turn yellow and the chlorosis occurs.
- The veins show a brown or black discolouration.

Pathogen: ***Xanthomonas compestrispv compestris***

- *X. campestris* is a rod-shaped Gram-negative bacteria characterized by its two cell walls and yellow pigment.
- It has a filamentous structure called hypersensitive response and pathogenicity (Hrp) pili that is attached to type III protein secretion system implementing the ability to transfer bacterial proteins to the plant and also motility in water

5. Radish mosaic

Symptoms:

- First appear as small, circular to irregular chlorotic lesion in between and adjacent to the veins.
- Little or no leaf distortion is noticed, and stunting or abnormal leaf formation rarely occurs.
- Severe yield loss in susceptible cultivars of radish is caused due to this viral disease.

Pathogen: Radish enation mosaic virus, radish mosaic comovirus

- Virus is transmitted by arthropods, by insects of the order **Coleoptera**; *Phyllotreta* ssp., *Epitrix hirtipennis* and *Diabrotica undecimpunctata*

Ex.No.9. DISEASES OF CASSAVA, COLACASIA AND YAM

Date:

DISEASES OF CASSAVA

1. Tuber rot

Symptoms

- Yellowing of leaves from the middle portion resulting in drooping
- Water-soaked brown to black lesions on tubers which coalesce further and spread over the entire tubers.
- Infected tubers emit a foul smell

Pathogen: *Phytophthora palmivora*

- Mycelium is hyaline, Coenocytic and branched. Asexual spore is Zoospores and Sexual spore is Oospores
- Primary spread is through soil borne Oospores and secondary spread is through wind and water borne zoospores

3. Brown leaf spot

Symptoms

- Spots appear on both sides of leaf
- On upper surface the spots appear brown with distinct dark border.
- On lower surface lesions have less distinct margin with grey centre due to the production of condiophores and conidia.
- The lesions become angular as they are limited by the veins. Leaves dry and drop.

Pathogen: *Cercospora henningsii*

- Sexual stage – *Mycosphaerella manihotis*.
- Geniculate conidiophores bears pale olivaceous both ends blunt 2 to 8 septate conidia.
- Black perithecia bears asci with 8 ascospores.
- Primary spread is through soil borne ascospres and secondary spread is through wind borne conidia

4. Indian cassava mosaic

Symptoms

- Mosaic disease with chlorotic areas.
- Leaves distorted, reduced in size ,misshapen and twisted with bright yellow area separated by normal green tissue.
- Plants stunted with reduced leaf canopy and stem girth.
- Heavy reduction in yield and tuber splitting

Pathogen: Indian Cassava Mosaic Virus (ICMV)

- DNA virus present in pairs as Geminate particles

- Vector : White fly –*Bemisia tabaci*

DISEASES OF COLACASIA

1. Phytophthora leaf blight

Symptoms

- The early stages of the disease are characterized by small circular water-soaked lesions, generally dark brown or purple.
- A clear amber fluid exudes from the center of the lesion.
- This liquid turns bright yellow or dark purple when it dries. The lesions rapidly enlarge and take on a zonate appearance.
- After initial establishment lesion development is rapid until the leaf is entirely colonized and collapses.

Pathogen: *Phytophthora colocasiae*

- *Phytophthora* produces coenocytic mycelium with sporangiphore bearing papillate sporangia which bears the zoospores.
- Primary spread is through oospore, dormant mycelium in plant debris and secondary spread is through zoospores produced in sporangia

2. Pythium rot

Symptoms

- The normally firm flesh of the corm is transformed into a soft, mushy, often malodorous mass.
- In wetland culture, the root system is destroyed except for a small fringe near the apex of the corm.
- The plants become stunted, with leaf stalks shortened and leaf blades curled and crinkled, yellowish and spotted.

Pathogen : *Pythium aphanidermatum*

- Coenocytic mycelium ,produces sporangiospore bearing irregular shaped sporangia which bears the vesicle. Inside the vesicle the zoospores are produced.
- Primary spread is through soil borne oospores and secondary spread is through water borne zoospores

3. MOSAIC

Symptoms:

- Plants generally become asymptomatic three to four months after initial symptom expression.
- The foliar symptoms include a dispersed and veinal mosaic pattern on the leaves.
- Leaf distortion is generally mild to moderate.

Pathogen: *Dasheen Mosaic virus*

- It is a stylet-borne virus carried by aphids *Myzus persicae.*

DISEASES OF YAM

1. Anthracnose

Symptoms

- Symptoms appeared at first as small dark brown or black lesion on the leaves, petioles and stems.
- The lesion is often surrounded by a chlorotic halo enlarged and coalesces, resulting in extensive necrosis of the leaves and die-back of the stem

Pathogen: *Colletotrichum gloeosporioides*

- Pathogen produces conidia single celled, hyaline slightly curved with oil globule.
- Asexual fruiting body is acervuli
- Primary spread is through dormant mycelium and ascospores from infected debris and secondary spread is through wind borne conidia

2. Dry rot

Symptoms:

- Symptoms though vary with varying coloration depending on the invading Pathogen, the infected tissues become hard and dry.
- The infected tubers first turned grey and then black, such tubers become pulverulent, breaking into small dry particles.

Pathogen: *Botryodiplodia theobromae*

- Inside the pycnidia, conidiogenous cells produce hyaline thin walled pycnidiospores which become brown, thick walled, two celled with longitudinal striations.
- Primary and Secondary spread is through air borne conidia

3. Collar rot:

- Collar rot is commonly found in two to three months old plants.
- The collar region is get rot which leads to death of the plants.
- In severe cases leaf become brownish and dry leads to death of the plant.

Pathogen: *Sclerotium rolfsii* and *Rhizoctonia solani*

- The fungus overwinters as a sclerotium, which is a dense mass of hyphae with a hard outer shell.
- Mustard like sclerotia is produced by *S. rolfsii* and spongy sclerotia are produced by *R.solani.*

Ex. No.10 **FIELD VISIT/ EXPOSURE VISIT TO HILLY FRUITS/ VEGETABLES AND PLANTATION CROPS / MUSHROOM UNIT**

Date:

Ex. No. 11 **DISEASES OF CHILIES, TURMERIC AND GINGER**

DATE:

DISEASES OF CHILLIES

1. DAMPIN

G OFF

Symptoms

- Pre-emergence damping off: seed rotting poor germination
- Post-emergence damping off: girdling of stem, toppling down of seedling

Pathogen: *Pythium aphanidermatum*

- *Pythium* produces coenocytic mycelium with sporangiophore bearing irregular shaped sporangia.
- The sporangia put forth vesicle which bears the zoospores
- Sexual spore is oospore

2. POWDERY MILDEW

Symptoms

- Infects the lower leaf surface as small, whitish powdery-like colonies.
- The upper surface of the foliage develops yellow spots. As the disease develops, the older colonies of the fungus may turn a dirty white color with age.
- The severely affected leaves turn yellow, then brown and fall off. Chlorotic and necrotic spots of the leaves, branch die-back, and dwarfing were the main symptoms, which were followed by pod drop.
- Generally, the older leaves are affected first and the disease gradually moves up the plant.
- Crop yields and fruit quality may be reduced through loss of foliage.

Pathogen: *Leveillula taurica* (asexual stage *Oidiopsis sicula*)

- The mycelium is endophytic bears condiophore and conidia (oidiopsis type)
- Formation of conidia singly (Pseudoidium type) on long lengthy conidiophore
- The size and shape of conidia mainly ellipsoid–ovoid
- Sexual spores are ascospores from chasmothecium

- **3. CERCOSPORA LEAF SPOT**

Symptoms

- Small circular brown spots light centre surrounded by dark band
- Spots on petiole, branches, peduncle
- Leaves wither and drop

Pathogen: *Cercospora capsici*

- Conidiophores bears conidia which are sub hyaline to coloured, obculate

- Sexual spore is ascospores from pseudothecia

3. DIE-BACK AND FRUIT ROT / ANTHRACNOSESymptoms

- **Die-back:** Necrosis of twigs from tip backwards causing die back of the branches.
- Twigs -Brown, straw coloured lesions having large number of acervuli
- **Fruit rot:** Small black circular spots on skin of ripe fruits
- Fruit turns straw coloured, numerous black acervuli formed in concentric rings
- Seeds covered with fungal hyphae, turn rusty, lose pungency
- Diseased fruits shrivel and dry up

Pathogen: ***Colletotrichum capsici***

- Mycelium septate. Conidiophore bears the conidia which are falcate, hyaline unicellular with narrow ends.
- Acervuli and setae present

4. BACTERIAL LEAF SPOTSymptoms

On Leaf

- Small, circular or irregular, dark brown or black greasy spots on leaf
- Petioles and stems also affected
- Cankerous growth and wilting of branches

On Fruits

- Round raised water soaked spots with a pale yellow border
- Bacterial ooze

Pathogen: ***Xanthomonas vesicatoria***

- Bacteria monotrichous, gram negative, rod shaped bacteria
- Mode of spread is by irrigation water and rain splash

5. CHILLI MOSAIC VIRUSSymptoms

- Mottling of yellow and green colour of leaves
- Margins curled inside
- Leaves develop depression, raised areas and puckering in the leaf blade
- Stunted plants with few flowers

Pathogen: Cucumber mosaic virus

- It is a RNA virus
- Transmission is by *Aphis gossypii*, *A. craccivora*

6. LEAF CURL VIRUSSymptoms

- Folded upward like a boat like structure

- Curling of leaves; Leaves small, internodes shortened; Plants distorted, stunted, unproductive

- Fruits small deformed

Pathogen: Chilli leaf curl virus

- It is a Gemini virus having DNA as nuclear material
- Vector is white fly *Bemisia tabaci*

DISEASES OF TURMERIC

1. RHIZOME AND ROOT ROT

Symptoms

- Basal portion of shoot watery and soft.
- Root system reduced, Rhizome decay becomes brown and soft.
- Leaves exhibit gradual drying.
- Appearance of diseases in patches.

Pathogen: ***Pythium aphanidermatum***

- Inter and Intra cellular mycelium. Zoospores are reniform, biflagellate, oogonia are spherical, antheredia is often curved.
- Oospores are spherical with smooth wall.

2. LEAF SPOT

Symptoms:

- Brown spots on upper surface of leaf.
- Centre greyish white, thin with numerous black dot like acervuli arranged in concentric rings. Yellow halo around spots.
- In severe cases leaves dry up and field presents a scorched appearance.

Pathogen : ***Colletotrichum capsici***

- It produces acervuli which is rounded or irregular in shape. Conidiophores are simple, septate.
- Conidia are cylindrical, non-septate with oil globules.

3. LEAF BLOTCH

Symptoms

- Spots on both side of leaf.
- Infected leaf reddish brown appearance.
- The functional area of leaf reduced.

Pathogen: ***Taphrina maculans***

- Obligate parasite.
- Septate, subcuticular, hyaline, intercellular and branched mycelium which does not produce ascocarp (naked asci).
- Asci are produced individually which bears eight ascospores.

DISEASES OF GINGER

1. RHIZOME ROT/ SOFT ROT

Symptoms

- Basal portion of the plants shows a water soaked brown colour and becomes soft.
- Leaves pale and yellowing of leaves.
- Withering and drying of leaves.
- Shoot easily pulled out.
- Tissues rot and fibrovascular strands lie isolated.
- Roots rot and become soft.

Pathogen : *Pythium aphanidermatum*

- Inter and Intra cellular mycelium.
- Zoospores are reniform, biflagellate, oogonia are spherical, antheredia is often curved
- Oospores are spherical with smooth wall.

2. LEA
F SPOT

Symptoms

- Brown spots on upper surface of leaf.
- Centre grayish white, thin with numerous black dot like acervuli arranged in concentric rings. Yellow halo around spots.
- Severe cases leaves dry up and field presents a scorched appearance.

Pathogen: *Colletotrichum zingiberis*

- It produces acervuli which is rounded or irregular in shape. Conidiophores are simple, septate.
- Conidia are cylindrical, non-septate with oil globules.

Ex.No.12DATE:

1. STEM GALL / TUMOURSymptoms:

DISEASE OF CORIANDER, CARDAMOM, BLACK PEPPERAND VANNIL

A DISEASES OF CORIANDER

- Tumor like swelling on leaf vein, leaf stalks, peduncles, stem and fruits.
  - The elongated swelling gives a hanging appearance to the leaves.

Pathogen: ***Protomyces macrosporus***

- Mycelium septate .Scattered cells in the hyphae swell and form globose bodies which later develop into chlamydospores.
- Chlamydospores germinate and form sporangium which releases ephemeral zoospores.
- Primary spread is by Ascospores and secondary spread by Budded conidia from ascospores

2. W ILT Symptom s:

- Wilting is sudden
- Drooping of terminal portion ,withering and drying of leaves
- Leaves become pinkish yellow to yellow and sterility is noticed

Pathogen: ***Fusarium oxysporum fsp. corianderii***

- Soil borne fungus with hyaline septate mycelium
- Produces microconidia, macroconidia, and chlamydospores

3. POWDERY MILDEWSymptoms

- White circular patches of powdery growth covers the leaf surface
- Affected leaves became distorted and dries up.

Pathogen: ***Erysiphe polygoni***

- Ectophytic mycelium , septate produces conidiophore which bears chain of conidia
- Mycelium hyaline and septate. Conidiophores bear chain of conidia
- Sexual spores are ascospores from chasmothecium

DISEASES OF CARDAMOM

1. DAMPING OFF /RHIZOME ROT /CLUMP ROT

Symptoms

- Pale yellow young foliage.
- Rotting of rhizomes.
- Shoots become very brittle and later collapse

Pathogen: ***Pythium vexans***

- Inter and Intra cellular mycelium. Zoospores are reniform, biflagellate,
- Oogonia are spherical, antheredia is often curved.
- Oospores are spherical with smooth wall.

2. AZHUKAL DISEASE /CAPSULE ROT

Symptoms:

- Large, irregular water soaked dirty black colour lesions appear on mature leaves.
- The leaves shred and get attached to the pseudostem
- Grayish patch of irregular brownish margin seen on the base of the leaf sheath.
- The basal portion of the pseudo stem breaks.
- Small light brown lesions develop on the tender fruits which fall prematurely.
- Blackish discolouration on the fruit wall.
- The tips of the inflorescence rot.

Pathogen: ***Phytophthora nicotianae var. nicotianae***

- Inter cellular mycelium with haustoria.
- Zoospores are reniform, biflagellate, oogonia are spherical,
- Antheredia is amphigynous and often curved.
- Oospores are spherical with smooth wall.

3. CHENTHAL DISEASES / LEAF BLIGHT

Symptoms

- Appearance of elongated water soaked lesions and leathery in appearance.
- In advanced stages, lesions are brown to dark with yellow halo.
- Withering and wilting of pseudo stem
- Drying of inflorescence tip to downward and presents a burnt appearance.

Pathogen: ***Colletotrichum gloeosporides***

- It produces acervuli which is rounded or irregular in shape. Conidiophores are simple, septate.
- Conidia are cylindrical, non-septate with oil globules.
- Sexual spore is ascospores

4. MOSAIC/ KATTE DISEASESymptoms:

- Thin chlorotic flecks on youngest leaves of stem which develop into pale green stripes running from midrib to leaf margin parallel to veins
- All leaves emerging subsequently have stripes; symptoms then spread to all tillers

Pathogen: Cardamom mosaic virus

- It is a RNA virus belongs to Poty virus group
- Vector is aphid *Pentalonia nigronervosa* fsp *.caladii*

DISEASES OF BLACK PEPPER

1. Foot rot / Quick wilt

Symptoms

- On the upper surface black coloured water soaked lesions appear.
- Later spots enlarge in size and cover the entire leaf surface and produces concentric lesions.
- Pathogen affects the young branches and causes drying of branches from tip downwards and exhibits dieback symptom.
- Blackening of collar region
- Infection starts from the main roots or on the feeder roots. Progresses from the feeder root to the lateral roots and finally to the main roots. The root system is weakened leading to death of the vine.

Pathogen: ***Phytophthora capsici***

- Hyaline , branched, coenocytic mycelium
- It produces sporangia, sporangia are pedicelled, spherical / oval
- Resting spores are Oospores

2. ANTHRACNOSE / POLLUSymptoms

On leavess

- Produces grey circular / irregular necrotic spots with grey colour centre and dark brown margin.
- Spots enlarge in size and covers the entire leaf surface and exhibits shot hole symptoms.
- Produces black dot like Acervuli at the centre of necrotic spots.

On berries

- Causes internal rotting / browning of tissues. causes black colour crack / split on affected berry.

Pathogen: ***Collecotrichum gloeosporioides***

- Mycelium is septate and branched
- Conidiophore bears the conidia which are falcate ,hyaline unicellular with narrow ends
- Acervuli and setae present
- Sexual spores are ascospores

3. CERCOSPORA LEAF SPOTSymptoms:

- Produces circular / irregular reddish brown spots in large number on the upper surface of leaves.
- Spots are surrounded by yellow border,
- Later these spots join together and cover the entire leaf surface.

Pathogen: ***Cercospora capsici***

- Produces conidiophore, conidia multiseptate / 1-5 septate, straight / slightly curved, hyaline in nature.
- Conidiophores bears conidia which are sub hyaline to coloured , obculate
- Primary spread is by Ascospores from the infected plant debris and secondary spread by wind borne conidia

DISEASES OF VANILLA

1. Black rot

Symptoms

- Water-soaked green to black rot of stems, leaves and/or pods
- thin white mycelium may be visible in infected tissues
- disease usually begins at the apical part of the plant and spreads to leaves, stems and all other parts of the plant

Pathogen: *Phytophthora* spp.

- Hyaline , branched, coenocytic mycelium
- It produces sporangia, sporangia are pedicelled, spherical / oval
- Resting spores are Oospores

2. Root and stem rot

Symptoms:

- Fungus causes brown lesions on roots which turn brown and dry out
- plants begin to rot at the apical tip and stop growing
- plant begins to produce new roots from apical tissue
- if there is not enough moisture, stems dry out and crack longitudinally
- cracks will eventually cover the whole stem and the plant will die

Pathogen: *Fusarium batatatis*

- Soil borne fungus with hyaline septate mycelium
- Produces micro conidia, macro conidia and chlamydospores

3. Anthracnose

Symp

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- Small, sunken, dark brown spots on leaves, fruits, stems and/or flowers
- Infected fruits dropping from plants before they reach maturity
- Damage to fruit is more pronounced during warm and humid periods of the growing season
- Symptoms generally develop first on apical parts of plant and spread to leaves and stems

Pathogen: ***Colletotrichum spp***

- Mycelium is septate and branched
- Conidiophore bears the conidia which are falcate ,hyaline unicellular with narrow ends
- Acervuli and setae present
- Sexual spores are ascospores

4. Rust

Symptoms:

- Yellow to orange pustules on undersides of leaves which enlarge and coalesce causing the entire leaf to dry out
- Plant development slows and defoliates and dies

Pathogen: *Uromyces joffrini*

- It is an biotroph
- Produces ehinulated single celled uredospores and single celled teliospores with thickened apex

Ex. No. 13 **DISEASES OF ROSE, JASMINE, MARIGOLD AND CROSSANDRA**

Date:

DISEASES OF ROSE

1. POWDERY MILDEW

Symptoms

- Leaves covered with greyish white, powdery fungal growth.
- Young leaves curled and distorted.
- Diseased buds fail to open.
- Flowers discoloured, dwarfed and dried.

Pathogen: ***Sphaerotheca pannosa***

- Ectophytic mycelium, septate produces conidiophore which bears chain of conidia
- Chasmothecia bears single ascus with 8 ascospores with myceloid appendages.

2. DIE BACK

Symptoms:

- Twigs dry from tip downwards.
- Twigs become brown to dark brown or black and infection spreads to roots.
- Browning of internal tissues, plant kills.

Pathogen: ***Diplodia rosarum***

- Produces black pycnidia which bear dark coloured 2 celled pycnidiopores.
- Perithecia produce ascus which bears ascospores.

3. BLACK SPOT

Symptoms:

- Black spot on the leaves.
- Spots more or less circular, irregular fibrillose border due to the radiating strands of mycelium.
- Plant blossoms poorly.
- Disease spreads on to stem and flowers.
- Blackened blisters on stem with dotted pustules.

Pathogen: *Diplocarpon rosae*

- Acervuli bear the hyaline two celled fusiform conidia.
- Apothecium bears the asci which contains 8 ascopores

4. RUST

Symptoms:

- Under side of the leaves and stem show orange to lemon yellow pustules.
- Turns brick red representing uredial stage.
- Later turns black representing teliospore stage.
- Leaves turn yellow, deformed and fall prematurely.

Pathogen: *Phragmidium mucronatum*

- Uredopores are ovate echinulate orange yellow borne on short pedicels.
- Teliospores are dark coloured cylindrical 6 to 8 celled with a pointed papilla borne on long persistent pedicels.
- They are hyaline and swollen at the base.

DISEASES OF JASMINE

1. LEAF BLIGHT

Symptoms

- Dark brown concentric rings seen.
- Burnt like fire, leaflets dry and fall off.
- Petioles, stem, calyx and tubular corollas affected.

Pathogen: ***Alternaria jasmini***

- Fungus possess brown colured, septate , branched mycelim
- Muriform conidia with acropetal succession
- Asci and ascospores are formed inside Pseudothecium

2. CERCOSPORA LEAF SPOT

Symptoms:

- Circular to irregular reddish brown spots covers entire leaf.
- Leaves become hard and brittle.
- Vegetative buds and young branches affected leads to defoliation.

Pathogen: ***Cercospora jasminicola***

- Hyaline , multiseptate , needle shaped conidia are produced by the fungus
- Sexual spores are ascospores produced in pseudothecia

3. RUST

Symptoms:

- Attacks all aerial parts like leaves, stems and inflorescence and cause blisters or tumors on the plant.
- Orange coloured pustules on both the surfaces of leaves. Infected portions become hypertrophied.
- Orange coloured cankers are seen on the stems and twigs.
- Infected flower buds are swollen and deformed.

Pathogen: ***Uromyces hobsonii***

- It is an autoecious macrocyclic rust fungus
- The urediniospores are round to ovate, light brown echinulate, with -4 equatorial germ pores
- The teleutospores are dark brown, one celled, mostly ovate, thick-walled

4. PHYLLODY: PHYTOPLASMA DISEASE

- Leaves are small, malformed and closely arranged.
- Flowers transformed into green leaf like malformed structure.
- Panicles are closely packed.

- **Mode of spread**: Transmitted by grafting and white fly: *Dialeurodes kirkaldii*

DISEASES OF MARIGOLD

1. FUSARIUM WILT

Symptoms:

- Yellowing and drooping of leaves
- Vascular browning of stem
- In the field the infected plants show wilting.

Pathogen: *Fusarium oxysporum* f.sp. *callistephi*

- Fungus produces 3 types of spores
- Microconidia-Ovate / elongate / 1 celled, hyaline
- Macroconidia – Spindle shaped, tapered, 3-4 septate hyaline
- Chlamydospores - Terminal or Intercalary

2. LEAF SPOT AND BLIGHTSymptoms:

- Brown necrotic spots develop on leaves, which get enlarged at the later stage of infection.
- The entire foliage gets damaged and results in poor vegetative growth

Pathogen: *Alternaria, Cercospora* and *Septoria sp*.

- *Alternaria* species produces muriform conidia
- *Cercospora* produces needle shaped multiseptate conidia
- *Septoria* produces hyaline multiseptate curved conidia

DISEASES OF CROSSANDRA

1. WILT

Symptoms:

- Wilt is observed in patches. In the field the disease is observed one month after transplanting.
- Leaves of infected plants become pale and droop. Margin of the leaves show pinkish brown discoloration.
- The discoloration spreads to the midrib in a period of 7 to 10 days.
- Stem portion gets shrivelled. Dark lesions are noticed on the roots extending upto collar region which result in sloughing off the cortical tissue

Pathogen: *Fusarium solani*

- Fungus produces 3 types of spores
- Microconidia-Ovate / elongate / 1 celled, hyaline
- Macroconidia – Spindle shaped, tapered, 3-4 septate hyaline
- Chlamydospores - Terminal or Intercalary

2. STEM ROT

Symptoms:

- The Pathogen also causes pre-emergence damping off, Brown to black lesions develop on stem just above soil level and result in girdling of the stem.
- The lesions extend to the upper part of the stem and results in collapse of seedlings.
- The roots are also rotted.

Pathogen: *Rhizoctonia solani*

- Septate mycelium. Sclerotia are irregular brown to black.
- Produces terminal and intercalary chalamydospores.
- Perfect stage: *Thanatephorus cucumeris*. Basidia with basidiospores are produced

3. LEAF BLIGHT

Symptoms:

- The symptoms of leaves consist of the development of brownish, depressed necrotic areas surrounded by reddish and slightly raised margins.
- Initially the spots appear as brownish specks but become darker as they expand.
- The lesions are more prominent on lower leaves and confined to the margins.
- Infected leaves roll up, shrivel and drop off, leaving a barren stem with a whorl of young leaves at the top.

Pathogen: *Colletotrichum crossandrae*

- It produces acervuli which is rounded or irregular in shape. Conidiophores are simple, septate.
- Conidia are cylindrical, non-septate with oil globules.

4. LEAF SPOT

Symptoms:

- This disease was first reported from Tamil Nadu during 1972. Infected leaves show small, circular or irregular yellow spots on the upper surface.
- They soon enlarge turn brown and develop dark brown concentric rings.
- Infected leaves become yellow and drop off prematurely.

Pathogen: ***Alternaria amaranthi*** **var. c*rossandrae***

- Primary spread is through Ascospores and secondary spread by wind borne conidia

Date:

DISEASES OF TUBE ROSE

1. Blossom blight

- **Symptoms**
  - Light brown lesions on the petals and soon darken and results in drying up of the affected portion.
  - The blighted blossoms drop off and infects flower stalk and tips turn brown

Pathogen: *Fusarium equiseti*

Fungus produces 3 types of spores

- Microconidia-Ovate / elongate / 1 celled, hyaline
- Macroconidia – Spindle shaped, tapered, 3-4 septate hyaline
- Chlamydospores - Terminal or Intercalary

2. Leaf Spot

- The disease appears as brown spots with faint concentric rings on midrib.
- Circular to oval spots are seen on peduncle
- Infected leaves and peduncles become necrotic and dry up.

Pathogen : *Alternaria polyanthi*

- The pathogen produces cylindrical conidiophores, which are pale grey-yellow coloured, straight or curved, geniculate, simple or branched, septate and bear single conidium.
- Conidia are cylindrical to long ellipsoid, straight or slightly curved, pale grey-yellow to pale brown, 1 to 2 septate with longitudinal septa.

3. Wilt and stem rot / Foot and tuber rot

- Disease appears in patches.
- Yellowing and drooping of leaves followed by drying of plants.
- Fungal mycelial mat is seen at the base of the infected plant near the soil line.
- The roots of diseased plants rot and plant wilts and die.
- Brown coloured mustards seed-like sclerotia are seen on the surface of the diseased stem tissues and at the soil level near the root region.

Pathogen: *Sclerotium rolfsii*

- Septate mycelium. Sclerotia are mustard like and dark brown.

3. Blight / Leaf and Flower Spot:

Symptoms

- The disease appears during rainy season. Reddish brown and oval spots coalesce and blight the leaves

- Infected flowers show dark brown spots and ultimately the entire inflorescence dries up.

Pathogen: ***Botrytis elliptica***

- Septate, branched and hyaline mycelium. Blakish, round or elliptical, irregular sclerotia appear on the diseased tissues which help the fungus to perpetuate.

5. Flower bud rot

Symptoms

- It occurs mainly on young flower buds and results in dry rot of buds and brown, scorched and necrotic discolouration of peduncles.
- Affected buds shrivel and dry.

Pathogen: *Erwinia* sp.

- Rod shaped gram negative bacterium with peritrichus flagella

DISEASES OF CARNATION

1. **Stem and Root Rot**

Symptoms

- Wilting of plants
- Infected plants express the presence of brown discolouration on the collar region
- death of plant

Pathogen: *P. nicotianae* var. *parasitica*

- Inter cellular mycelium.
- Zoospores are reniform, biflagellate,
- Oogonia are spherical, antheredia is amphigynous and often curved.
- Oospores are spherical with smooth wall.

2. ***Sclerotinia* stem rot**

- Stem rot affected plants wilt gradually and the wilting is not observed on one side as *Fusarium* wilt.
- The leaves become straw coloured.
- The affected stems are hollow.
- Longitudinal section of the affected stem reveals the presence of irregular brown coloured sclerotia of irregular shape.
- In the affected plants, vascular system turns brown

Pathogen: *Sclerotinia sclerotiarum*

- Mycelium of the fungus is hyaline, septate, branched and radiating on infected parts.
- The fungus produces hard, irregular, flattened sclerotia during asexual reproduction.
- The sclerotia germinate and produce apothecia with asci and ascospores

3. **Collar rot/ Stem rot/ Root rot:**

- *Rhizoctonia solani* infect carnation plants at or just below the soil level.
- Affected plants are stunted.
- Lesions develop on the stem and the stem breaks off.
- Subsequently, the entire plant wilts and dies.

Pathogen: *Rhizoctonia solani*

- It produces light brown coloured mycelium which is septate , and branched with constriction
- It produces spongy, irregular sclerotia

4. **Sclerotium root rot / basal rot**

- Leaves of the carnation plants infected by *Sclerotium rolfsii* turns pale green and dry.
- Infected plants exhibit the presence of white, cottony growth of mycelium at the collar region of the stem leading to rotting of the stems at the soil level.
- During severe cases of infection, Rotting of stem starts at the pathogen spread to the leaf.
- Subsequently, it leads to rotting of the stem and death of the plants.
- During the advanced stages of infection, on the soil level and at the basal portion of the stem white to dark brown spherical sclerotial bodies are noticed

Pathogen: *Sclerotium rolfsii*

- The mycelium of the fungus is hyaline, branched at clamp connections and septate.
- The abundant brown mustard like sclerotia are produced

5. **Wilt**

Symptoms

- Yellowing of leaves, withering of leaves at the basal portion, and yellowing of midribs.
- The infected leaves turn chlorotic and finally wilt.
- During certain occasions, a portion of the plant wilts and subsequently spread to all the portions of the plant

Pathogen: *Fusarium oxysporum f. sp. dianthi*

- Produces microconidia, macroconidia, and chlamydospores
- Primary spread is by Soil borne chlamydospores and Secondary spread by conidia

6. ***Alternaria* leaf spot / blight**

Symptoms

- Small purple lesions on leaves and later turn as greyish-brown spots.
- During favourable conditions, lesions enlarge and merge together and results in blighting of leaves.
- Lesions also spread from the leaf to the stems and lead to girdling of the stem

Pathogen: *Alternaria dianthi*

- Conidia are dark brown or olive-brown in colour, short beaked,
- Conidia are borne in long chains, oval and bean shaped with 3-5 transverse septa.

7. **Fairy ring leaf spot**

Symptoms

- Leaf spot is characterized with pin head like necrotic tan spots on the leaf and leaf sheath.
- The margin of the spots is purple to dark purplish.
- During favourable conditions, the spots enlarge as circular – oval spots with grey centre.
- Conidiophores and conidia develop in the spots. Dark spores form in spots. This brownish

growth appears as dull and dark bands, giving the name „fairy ring" spot to the disease.

Pathogen: ***Cladosporium echinulatum***

- Conidia solitary or in short and unbranched chains, mostly of two types: small conidia ellipsoid to subcylindrical, 0-1 septate, smooth to minutely verruculose, pale brown
- large conidia ellipsoid to cylindrical, often soleiform, up to six septa, somewhat septa appearing curved and brown,

8. Rust

Symptoms

- Rust symptoms are initially characterized with light green coloured lesions.
- On the lesions small brown pustules with powdery mass of brown spores develop on the leaves.
- During severe cases of infection, the lesions also spread to the stems.
- Due to high disease intensity, plants wither and affect the growth and flower quality. Severe infection leads to drying of leaves and stems.

Pathogen: ***Uromyces dianthi***

- The uredospores are spherical, brownish yellow in colour, loosey echinulated with 4-8 germ pores.
- Teliospores are round to oval, brown, single celled with unthickened apex and the walls are rough, brown and warty.

9. Grey mould

Symptoms

- Symptoms initially appeared as water-soaked brown lesion on the petals.
- Later, tan to grey, fuzzy mould, composed of thousands of spores, borne in grape like clusters covered the entire flower, under humid conditions.
- Fuzzy mould covered the flowers and flower buds and left them to choke.
- Under severe conditions, mold covers the entire plant and leads to complete drying.
- During prolonged period of sunshine without rain, irregular black resting bodies (sclerotia) of the fungus were found inside the split opened flowers

Pathogen: ***Botrytis cinerea***

- Hyaline, septate hyphae and produced grape bunch like conidia
- Sclerotia germinated both by myceliogenous and sporogenous modes

10. Bacterial wilt

- Infected plants exhibit greyish green foliage followed by sudden wilting and death of the plants.
- Roots of the affected plants rot and emit bad odour.

- Affected vascular tissues turn yellowish to brown.

- Basal portion of the affected stems cracks.

Pathogen: *Burkholderia caryophylli*

- It is a gram negative , rod shaped motile bacteria with flagella

1. **Basal rot or bulb rot**

Symptoms

- Unlike other *Fusarium* diseases, it is not a vascular wilt but it is a rot of the cortical tissues of the root.
- Chocolate or bluish-grey rot that extends from the basal plate in the scales
- Scales detach at the basal plate and bulbs fall to pieces after digging
- Premature yellowing of the foliage, stunting and premature senescence.
- Flower buts wilt and fail to open.
- The vascular tissues of the infected stem turn in to dark brown colour.

Pathogen: *Fusarium oxysporum* f.sp. *lilii*

- Fungus produces 3 types of spores
- Microconidia-Ovate / elongate / 1 celled, hyaline
- Microconidia – Spindle shaped, tapered, 3-4 septate hyaline
- Chlamydospores - Terminal or Intercalary

2. Foot rot

Symptoms

- Stem at collar region is mostly attacked. Affected plants wilt and die
- Sometimes leaves and flowers on the upper plant parts are also affected.

Pathogen: *Phytophthora cactorum*

- Hyaline coenocytic mycelium.
- Sporangiophores are slender sympodially branched which bears elliptical non-papillate sporangia with slight apical thickening with kidney shaped, biflagellate zoospores.
- Sexual spore is oospore

3. Botrytis blight

Symptoms

- Orange to reddish browm, oval spots with yellow halo or with water-soaked margin appear on leaves.
- Brown spots appear on stem near soil level.
- Lesions on flowers are brown and in cool and moist weather flowers are converted into wet slimy masses covered with powdery spores.

Pathogen : *Botrytis elliptica*

- Hyaline, septate hyphae and produced grape bunch like conidia

- Sclerotia germinated both by myceliogenous and sporogenous modes.

4. **Anthracnose**

Symptoms

- The disease infects outer scales of the bulbs in the soil
- Small, brown spots appear on linear scales.

Pathogen: *Collectotrichum lilii*

- Mycelium is septate.
- Conidiophore bears the Conidia were hyaline, aseptate, falcate, fusiform, tapered gradually to each end.
- Appressoria were dark brown to black, mostly lobed, rarely circular to clavate. Acervuli and setae present.

5. Lily mottle virus

Symptoms

- Veil clearing, mosai mottling, chlorotic and yellow streaking, leaf curling and narrowing are the common symptoms on leaves.
- Color breaking in flowers

Pathogen: Lilly mottle virus

- It belongs to Poty virus group
- Vector: Aphids

DISEASES OF ORCHIDS

1. Black rot

Symptoms

- The disease appears as water soaked patches on leaves which quickly turn black from the tip
- The rot spreads down the leaf and makes it completely black.
- The infection begins at the rhizome but the rotten patch is seen at the tip of the leaf

Pathogen: *Pythium splendens*

- *Pythium* produces coenocytic mycelium with sporangiophore bearing irregular shaped sporangia
- The sporangia put forth vesicle which bears the zoospores

2. Wilt

Symptoms

- Wilting of leaves
- Abscission and decay of roots followed by the production of few, small short-lived flowers

Pathogen: *Fusarium oxysporium f.sp.cattleyae*

- Fungus produces 3 types of spores
- Micro conidia-Ovate / elongate / 1 celled, hyaline
- Micro conidia – Spindle shaped, tapered, 3-4 septate hyaline
- Chlamydospores - Terminal or Intercalary

3.Rust

Symptoms

- Yellow pustules covered with fine powdery masses of spores on leaves

Pathogen: *Hemileia americana*

- It produces orange segment shaped uredospores and turnip shaped teliospores
- It does not produce all five stages (microcyclic)
- Pyncnial and Aecial stages have not been observed

4.Leaf Spot

Symptoms

- Yellow leaf spot and irregular blemishes seen on both the surface of leaf may enlarge and slightly suncken and necrotic and turn purplish brown to black spots and cover entire leaf
- Mosaic pattern occurs on the upper leaf surface when large sections of the leaf are diseased and undersides can be covered with dots, the sporing bodies
- Heavily infected leaves usually fall

Pathogen : ***Pseudocercospora dendrobii***

- Conidiophores bears conidia which are sub hyaline to coloured, obculate.

- Ascospores from the infected plant debris

5. **Bacterial soft rot**

Symptoms

- Small, water soaked dark green spots on upper end of leaves
- Pseudobulbs of infected plants turn soft and pulpy and become yellow in color
- Foul smelling liquid oozes from the bulbs.

Pathogen : *Pectobacterium carotovorum subsp.carotovorum*

- Bacteria are non-spore forming, motile, short rod shaped

Ex.No.15. **DISEASES OF GLORIOSA, COLEUS , STEVIA AND ALOE**

Date :

DISEASES OF GLORIOSA

1. Root rot

Symptoms

- Ring the pustules is later ruptured irregularly exposing a powdery mass of brick red-colorInitially, brick red colored elliptical blisters or pustules, known as uredia, develop on the stem, leaf and leaf sheath.
- The epidermis coveed uredospores

Pathogen: *Sclerotium rolfsii*

- Septate mycelium. Sclerotia are mustard like and dark brown.

2. Lea f Blight

Sympto ms

- Water soaked black lesion on the leaves and drying of leaves

Pathogen: *Curvularia lunata*

- Well branched, septate, brown and smooth mycelium. Conidiophores are dark brown bears dark, 3 to 4 septate curved conidia

3. M osaic

Sym ptom s

- Leaves become chlorotic with reduced chlorophyll content
- It affects the flower and changes the original color
- **Vector : Aphid (**Glory lily mosaic virus)

DISEASES OF COLEUS

1. Wilt

Symptoms

- Yellowing and wilting of leaves
- Brown to black roots, oozing, putrefaction and decaying of roots and unhealthy plants

Pathogen: ***Fusarium chlamydosporum***

- Fungus produces 3 types of spores
- Micro conidia-Ovate / elongate / 1 celled, hyaline
- Micro conidia – Spindle shaped, tapered, 3-4 septate hyaline
- Chlamydospores - Terminal or Intercalary

2. Root rot

Symptoms

- Yellowing and drooping of the leaves,
- Blackening of the stem,
- Rotting of the root, basal stem and peeling of stem bark and root epidermis.
- The presence of black sclerotia was observed on the rotted portion.

Pathogen: ***Macrophomina phaseolina***

- The mycelium was initially hyaline and later became grey in colour.
- Sclerotia were minute, black, round to oblong or irregular in shape with mycelial attachment

3. Blight Disease

Symptoms

- Blight disease is common during monsoons or during period of high humidity.
- Symptoms include water soaked leaf spots that increased rapidly in size becoming light tan to brown and later necrotic.
- Severe infection results in defoliation and death of the plants.

Pathogen: ***Rhizoctonia solani***

- Septate mycelium. Sclerotia are irregular brown to black.
- Produces terminal and intercalary chlamydospores.
- Perfect stage: *Thanatephorus cucumeris*. Basidia with basidiospores are produced.

DISEASES OF STEVIA

1. Root Rot

- Yellowing and drooping of leaves, with wilting of plants and white cottony mycelial growth at the collar region.
- The mycelial growth spread to the stem and roots, with associated tissue rotting.
- On the diseased areas, brown sclerotia were observed.

Pathogen: *Sclerotium rolfsii*

- The mycelium of the fungus is hyaline, branched at clamp connections and septate.
- The abundant brown mustard like sclerotia are produced.

2. Leaf Spot

Symptoms

- Initially appeared as small circular spots, light brown in colour.
- Later, many became irregular and dark brown to grey, while others remained circular with concentric rings or zones.
- On severely infected leaves several spots coalesced to form large necrotic areas.
- On older leaves concentric spots were more common at the tips. Leaf spots varied from 2-18 mm in diameter.

Pathogen: *Alternaria alternata*

- Conidia dark brown or olive-brown in colour, short beaked, borne in long chains, oval and bean shaped with 3-5 transverse septa.

DISEASES OF ALOE

1. Base Rot

Symptoms

- The disease is common and occurs in abundance when there is too much water in the soil.
- The infection appears at the base of older or mature leaves which show yellowish brown rot.
- Under severe infection, the leaves droop and fall. This may lead to partial or complete defoliation of the plant depending on the severity of infection.
- Sometimes severe infection may lead to premature death of the plant.

Pathogen: ***Pectobacterium chrysanthemi***

- Bacteria are non-spore forming, motile, short rod shaped.
- Gram negative with peritrichous flagella

2. Lea
f Spot

Symptoms

- Small, circular to oval dark brown necrotic sunken spots located mostly on the leaf tip.

Pathogen: ***Alternaria alternata***

- The conidiophores were branched, straight and golden brown in colour.
- Conidia are dark brown or olive-brown in colour, short beaked, borne in long chains, oval and bean shaped with 3-5 transverse septa.

Ex.No.16. **MUSHROOM CULTIVATION**

MUSHROOM –TISSUE ISOLATION AND SPAWN PREPARATION

Date:

Tissue culture:

Tissue culture technique is used to bring the edible mushroom to pure culture so that the mushroom fungus can further be used to prepare spawn, which is an essential material for mushroom cultivation. This nucleus culture is grown on Potato Dextrose Agar medium in test tubes. A small tissue from a well-grown mushroom is aseptically transferred to agar medium in a test tube in a culture room. The test tubes are incubated under room temperature for 10 days for full white growth of fungal culture. This is further used for preparation of Mother spawn.

Procedure:

- Select well grown, disease free mushroom sample
- Take the mushroom and split open the mushroom longitudinally into two halves under aseptic conditions and pierce a small piece of tissue from junction of stipe and pileus
- Transfer tissues in to the PDA medium in the tube under aseptic condition
- The growth of mushroom mycelium takes place which covers the tube in 6-7 days and can be used as base culture

PREPARATION OF MOTHER SPAWN

Mother spawn

- Mother spawn is nothing but the mushroom fungus grown on a grain based medium.
- Wash the sorghum grains in water thoroughly to remove chaffy and damaged grains.
- Cook the grains in an autoclave / vessel for 30 minutes just to soften them.
- Take out the cooked grains and spread evenly over a Hessian cloth on a platform to remove the excess water.
- Mix calcium carbonate ($CaCO_3$) thoroughly with the cooked, dried grains @ 20 g / Kg
- Fill the grains in polypropylene bags up to 3/4th height (approximately 300-330 g / bag), insert a PVC ring , fold the edges of the bag down and plug the mouth tightly with non-absorbent cotton wool.
- Cover the cotton plug with a piece of waste paper and tie tightly around the neck with a jute thread.
- Arrange the bags inside an autoclave and sterilize under 20 lbs pressure for 2 hours.
- Take out the bags after cooling and keep them inside the culture room
- Transfer the mushroom base culture in to the sterilized sorghum bag
- Incubate the inoculated bags in a clean room under room temperature for 10 days for the mushroom mycelium grows on the sorghum grains to form the mother spawn

PREPARATION OF BED SPAWN

Bed spawn: The method of preparation of bed spawn was same as that of mother spawn. The cooking, filling and sterilization were similar to that of mother spawn. After sterilization, the bags are taken for inoculation. One mother spawn can be transferred to 25 to 30 first generation bed spawn and from this 750 to 900 second generation bed spawn can be prepared.

CULTIVATION OF OYSTER MUSHROOM

Pleurotus spp. can be grown indoors and any well-ventilated room would be suitable. A thatched shed with false roofing is an ideal room for successful cultivation of this mushroom, as the required temperature of 20- 25□ C and relative humidity of 80-85 % can easily be maintained. Bed spawn and mother spawn are prepared as above.

OYSTER MUSHROOM (*Pleurotus sp.)*

- Sub tropical mushroom
- Genus – more than 50 species
- Short Stipe , colour of stipe and pileus same
- distinct shell shape, soft, mostly white or pink, dull white, grey, yellow
- stipe laterally attached to pileus, decurrent gills
- Cultivated in thatched sheds
- Temperature : 25- 28ºC and RH of 80 to 85 %

Preparation of substrate:

Paddy straw is found to be the best substrate giving more bio efficiency. Paddy straw is chopped into bits of size 2-3” for easy handling and operation. There are three methods with which the chopped straw can be sterilized *viz*., Hot water treatment / Boiling method which involves boiling the paddy straw for 30 to 45 minutes, steaming in which the substrate is steamed under 15 lbs for 30 minutes, Chemical method which includes soaking substrate in 10 g of carbendazim and 120 ml. of formalin for 16 h. After these processes, the excess wateris drained from the substrate by spreading on a hessian cloth to get 60-65 % moisture capacity.

BED PREAPRATION AND CROPPING:

The cultivation of oyster mushroom is usually carried out in transparent polythene covers. The size of the cover should be 60 x 30 cm, with a thickness of 80 gauge.

- Take the polythene cover and tie the bottom end with a thread and turn it inwards
- Take out a well-grown bed spawn, squeeze thoroughly and divide into two halves.(Two beds are prepared from the single spawn bag)
- Fill the straw to a height of 3” in the bottom of polythene bag, take a handful of spawn and sprinkle over the straw layer, concentrating more on the edges.
- Fill the second layer of the straw to a height of 5” and spawn it as above.
- Repeat this process to get five straw layers with spawns.

- Gently press the bed and tie it tightly with a thread.
- Put 6 ventilation holes randomly for ventilation as well as to remove excess moisture

present inside the bed.

- Arrange the beds inside the thatched shed, (Spawn running room) following rack system or hanging system. Maintain the temperature of 22-25□ Cand relative humidity of 85-90 % inside the sheds.
- Observe the beds daily for the infestation of insect pests and moulds
- The fully spawn run beds should be transferred to cropping room in the thatched shed, where the diffused light and good ventilation are necessary for the button development.
- Open the bed cover and spray water on the beds from second day of opening using an atomizer.
- Two to three days after opening pinheads of mushroom button develop which will be ready for harvest with in another 4 days.
- Harvest the entire bunch of mushroom gently in the early hours of morning.

CULTIVATION OF MILKY MUSHROOM

The cultivation of milky mushroom *Calocybe indica* is usually carried out in transparent polythene covers. The size of the cover should be 60 x 30 cm, with a thickness of 80 gauge.

MILKY MUSHROOM

- Pure milky white colour
- similar to button mushroom in appearance
- Long stipe, sub bulbous at the base, centrally attached to stipe, no annulus or volva
- Pileus/ cap- smooth, convex later expanded
- Adnate to decurrent gills
- Long shelf life and more fibre (41%)
- Cultivated in polysheds
- Temperature requirement :30-35ºC; RH of 75 to 85 %

Preparation of substrate: Substrate preparation is similar to oyster mushroom.

Bed preparation: Bed preparation is similar to oyster mushroom.

Casing and cropping: In the case of milky mushroom, an extra process called casing has to be done to induce button formation. Casing is nothing but the application of thin layer of sterilizedsoil on the surface of mushroom bed to induce button formation. For casing, garden land soil rich in calcium is preferable. The soil is mixed with calcium carbonate @ 100 g/ kg and used asa casing medium and steamed in an autoclave or pressure for 45 minutes. After casing operation, the beds should be arranged inside the blue polythene covered pit tent. The fungus requires an optimum temperature of 30-35˚C and relative humidity of 80-85 per cent for the better growth and production of sporocarp. In addition, the fungus needs a light intensity of 2500- 3000 lux for production of buttons.

The fully grown beds are cut in to two halves and over each half casing soil is to be layered to 1 inch height and such cased beds should be kept inside the blue tent. Observe thebeds daily and spray water if necessary, to keep the beds wet. Watch for any contamination and insect pests. If noticed take necessary steps. Ten days after casing the small pin head buttons develop and with in another 7 days mushrooms are ready for harvest. Harvest the mushroom, clean it and pack it in a polythene bag for sales. Three harvests can be made from these beds. The mushroom yield of 350 –400 g can be obtained from 250 g dry weight of the straw, providing all optimum conditions inside the mushroom shed.

PADDY STRAW MUSHROOM- BED PREPARATION AND CROPPING

The cultivation of paddy straw mushroom can be done in a thatched house and also under the shade of a tree. Fresh, disease free paddy straw is the ideal substrate. In recent years, it is cultivated inside plastic film houses to maintain the temperature of around 25 -35□ Cand relative humidity of 75-80 %.

PADDY STRAW MUSHROOM

- Volva- distinct character
- pileus initially bell shaped, later umboniform
- stipe colour white and long (5-12 cm), pileus light brownish red
- Homothallic mushroom
- Cultivated in poly sheds and outdoor cultivation
- Temp: 30-35ºC, RH- 85%

Spawn: Paddy straw bits are soaked in water for 1 hour, excess water is drained and mixed with 10% horse gram powder and autoclaved in polythene bag at 15 lbs for 1 hour. After cooling, paddy straw base culture is transferred to the autoclaved paddy straw bits and the mycelium covers the bag in 6- 7 days which form the spawn

Circular compact bed method: Instead of bundled straw, twisted paddy straw can also be used for cultivation. At least ten kg paddy straw is necessary for preparing one bed.

- Make the straw into twists of about 5-8 m long and 5-10 cm diameter.
- Immerse the twists in water for 12 hr.
- Take out the straw and drain the excess water.
- Place them in a circular manner over a platform.
- Sprinkle the coarsely powdered horse gram and place small bits of spawn all along theperiphery as above.

- Build another layer as described above and spawn the layer.
- Build up 4-5 layers and spawn as usual.
- Compact the bed by pressing and cover it with a polythene sheet.

The beds are to be sprinkled with water to maintain 50 to 60 % moisture and the mushroom spawning is completed in 5-6 days and pinheads appear from 8-9th day and the mushroom is ready for harvest by 10th day. Within 20-22 days three harvests can be completed.

PRACTICAL MANUAL
AGS-604
Post-harvest Management and Value Addition of Fruits and Vegetables

Exercise No 1

Application of different types of packaging containers for shelf-life extension

The increased production of fruits and vegetables will have significance only when which they reach the consumer in good condition at a reasonable price. The existing post-harvest losses of fruits and vegetables could be considerably reduced by adopting improved packaging.

Packaging of fruits and vegetables is undertaken primarily to assemble the produce in convenient units for marketing and distribution.

Objects of packaging

1. To protect the produce from hazards of transport
2. Preventing microbial and insect damage
3. Minimizing the physiological loss in weight

Characteristics of packages

a) The package must have sufficient mechanical strength to protect the contents during handling, transporting and staking.
b) The packaging material must be free of chemical substances that could transfer to the produce and become toxic to man.
c) The package must meet handling and marketing requirements in terms to weight, size and shape.
d) The package should allow rapid cooling of the contents. Furthermore, the permeability of plastic films to respiratory gases could also be important..
e) Mechanical strength of the package should be largely unaffected by moisture content (when wet) or high humidity conditions.
f) The security of the package or ease of opening and closing might be important in some marketing situations.
g) The package must either exclude light or be transparent.
h) The package should be appropriate for retail presentations.

i) The package should be designed for ease of disposal, re-use, or recycling.

j) Cost of the package in relation to value and the extent of contents protection required should be as low as possible.

Different packaging for important frits and vegetables

Sr. No.	Types of packing	Commodity packed
1.	Flexible sacks (gunny bags)	Ber, lemon, lime, mango (raw), pear, sweet orange and different vegetables
2.	Bamboo baskets	Grape, guava, mango, papaya, tomato
3.	Earthen pots	custard apples, grapes
4.	Wooden boxes	Apple, apricots, cherry, litchi, mango, mandarin, pear, plum, sapota, capsicum
5.	Corrugated fibre box (CFB)	Apple, cherry, grape, pomegranate, all fruits and vegetables for export.
6.	Rigid plastic crates	Loose fruits and vegetables for cold storage, processing plants, nearby local markets and public distribution system.

New Packaging Material

Sr. No.	Types of packing	Speciality
1.	Corrugated fibre board (CFB) boxes	These are light in weight, easy to handle, hygienic and recyclable. These can be turned water resistant by the use of a suitable adhesive or was coating or a plastic film.
2.	Combination boxes	These are mad with plywood and CFB and give a high stack load capacity
3.	Corrugated polypropylene board boxes	These are light in weight, hygienic, water resistant, sturdy and have a light busting strength. These are useful in the multi-trip packaging.
4.	Plastic trays or crates	These are hygienic, light in weight, sturdy and recyclable and useful in the multi-trip packaging.
5.	Plastic woven sacks	These bags are made of high density polyethylene or polypropylene, light in weight and can be reused.

		These are used for packaging hard fruits to transport them over short distances.
6.	Moulded pulp trays or thermoformed plastic trays	These trays have the facility of cavities to hold individual apple fruit which prevents the fruit from rubbing against each other that often leads to bruising or surface cracks.
7.	Stretch wrapping	It is used for retail marketing of fresh produce in the form of cling plastic films for stretch wrapping
8.	Modified atmospheric packaging	In this packaging, the internal atmosphere can be manipulated with a combination of certain gases (O_2 & CO_2)and selection of suitable packaging material

Ventilation

Adequate ventilation should be given to the boxes which used to pack the fruits and vegetables. Holes should be provided on the surface (top and sides). This prevent the heat generation which can cause rapid product deterioration.

Exercise No 2

Effect of temperature on shelf life and quality of produce

Temperature is the characteristic of the postharvest environment that has the greatest impact on the storage life of vegetables. All vegetable deteriorate after they are harvested; only the rate at which the deterioration occurs can be changed.

It is well established that the deterioration of most agricultural products is a direct unction of temperature. Within the rage of temperatures bounded on the lower end by chilling injury or freezing and on the upper by heat injury. Deterioration of vegetables caused by physiological, pathological, or physical factors is a function of time and environment.

Postharvest losses of horticultural crops are estimated to be as high as 25% to 50% of the production due to poor postharvest handling techniques, mainly poor temperature management. Especially in some region of the globe such as tropical and subtropical regions and where refrigeration facilities are not available. A large quantity of onions (*Allium cepa* L.) is lost between the field and the consumer in India due to lack of adequate postharvest handling procedures. Good temperature management is, in fact, the most important and simplest procedure for delaying product deterioration. In addition. Optimum temperature storage retards the aging of vegetables. Softening, and textural and colorchanges as well as slowing undesirable metabolic charges, moisture loss, and losses due to pathogen invasion. Temperature is also the factor that can be most easily and promptly controlled. Optimum preservation of vegetable quality can only be achieved when the produce is promptly cooled to its optimum temperature as soon as possible after harvest.

Low temperature during the storage of fresh vegetables depress both the physiological activity of vegetable tissue and the activity of micro-organisms capable of causing spoilage of the product. In general, the lower the storage temperature, within the limits acceptable for each type of commodity (above the freezing point or chilling injury threshold,) the longer the storage life. For each horticultural commodity there is presumed to be an optimal postharvest storage temperature at which the rate of product deterioration is minimized. Vegetables are, in fact highly perishable products and losses due to inadequate temperature management are found to be mainly due to water loss and decay carrots (*Dacus carota*L.) should be stored at 0 to 1^0 C in order to maintain quality during long-term storage (between 150 and 190 days.) They also added that the carrot temperature should be reduced to about 0^0 C as soon as possible after harvest. And that the temperature should be maintained constant during the storage period. The optimum temperature for reducing decay of beets (*Beta vulgaries*) was 4 to 5^0 C rather that 0 to 1^0 C of 2^0 C to 3^0 C the storage life of cabbage is limited to 4 to 5 months when storage temperature is maintained at 7 to 8^0 C.

Effects of Storage Temperature on the Quality of Vegetables

The visible quality of the product that is the appearance of the product is perhaps the most important factor that determines the market value of fresh vegetables. When consumers were asked about fresh fruits and vegetables, ripeness, freshness, and taste were named by 96% as the most important selection criteria. While appearance and condition of the product came in second in order of importance.

1) *Appearance and Texture of Vegetables*

Colour, one of the major factor of product appearance, is a primary indicator of maturity or ripeness and is due to the presence of particular pigments in the product. Undesirable changes in the uniformity and intensity of colour can be observed when fruits and vegetables are not stored at recommended temperatures. Temperature can therefore have a direct effect on colour changes during storage of fruits and vegetables. For example, loss of chlorophyll in mango and tomato, yellowing of green vegetables such as broccoli is considered undesirable.

2) *Compositional Characteristics of Vegetables; nutritional Value*

Fruits and vegetables are rich sources of vitamins, particularly, Vitamin C and Vitamin A required in the human diet. However, the nutritional value of fruits and vegetables can also be greatly affected by storage temperature. In general, Vitamin C degradation is very rapid after harvest and increases as the storage time and temperature increases. The concentration of carbohydrates, sugars as well as organic acids in fruits and vegetables can also decrease when temperature increases. It is due to fact that, when temperature increases, the respiration rate of the product increases and complex carbohydrates and organic acids are transformed into glucose to provide substrate for respiratory processes.

In conclusion, good temperature management is recommended for fresh fruits and vegetables since it retards aging due to ripening, softening, textural and colour changes, undesirable metabolic changes and respiratory heat production that results from moisture loss, spoilage due to invasion by bacteria, fungi and yeast.

Optimum cold storage conditions & approximate storage life of fruits and vegetables

Passion fruit	6-7	85-90	3
	Temp (°C)	**RH (%)**	**Approx. storage life(weeks)**
Fruits			
Apple	0-2	85-90	20-30
Avocado			
Chilling tolerant varieties	4.4	85-90	4
Chilling sensitive varieties	12.5	85-90	2
Banana			
Cavendish green	13	85-90	3-4
Cavnedish ripe	12	85-90	1-5
Ney Poovan green	12	85-90	2-3
Ney poovan ripe	8	85-90	1
Ber	5-6	85-90	4
Citrus			
Coorg mandarin (main crop)	8	85-90	8
Coorg mandarin (rainy season)	8	85-90	6
Sathgudi orange (Moosambi)	8	85-90	16
Lime yellow	12-13	85-90	8
Lime green	12-13	85-90	7
Grape fruit	13-14	85-90	12
Custard apple	15	85-90	1.5
Date	6-7	85-90	2
Fig	1-2	85-90	6
Guava	10	85-90	2-5
Jackfruit	11-12	85-90	6
Litchi	2	85-90	8-10
Alphonso	12-13	85-90	4
Banganapalli	12	85-90	5-6
Papaya green	10	85-90	3-4
Papaya turning	9	85-90	2-3
Pineapple all green	9-10	85-90	4-6
Pineapple 25% Yellow	6-7	85-90	1-2

Pomegranate	7-8	85-90	10-12
Sapota mature	20	85-90	2
Strawberry	0	85-90	1
Vegetables			
Beans			
Snap beans	8-10	85-90	3-4
Winged beans	10	85-90	8-10
Beetroot	0-1	90-95	8-10
Brinjal	10	90-95	2
Cabbage(wet season)	0-2	90-95	4-6
Cabbage(dry season)	0-2	90-95	12
Capsicum(green)	7-8	85-90	3-5
Carrot topped	0-2	90-95	20-24
Cauliflower	0-2	90-95	7
Coriander leaves	0-2	90-95	4-5
Chow chow	12-13	90-95	3
Cucumber	10-11	90-95	2
Garlic(bulbs) dry	0	65	28-36
Ginger	8-10	75	16-20
Gourd, bottle	8-9	85-90	4-6
Gourd, snake	18-20	85-90	2
Muskmelon, Honey dew	7-8	85	4-5
Okra	10	90	1.5
Onion, Red	0	65-70	20-24
Onion, white	0	65-70	16-20
Pea, green	0	90-95	2-3
Poato	4	85	30-34
Pumpkin	12-15	70-75	24-36
Radish, topped	0	90-95	3-5
Squash	12-15	70-75	8-24
Sweet Potato	10-12	80-90	13-20
Spinach	0	90-95	10-14
Tomato			
Mature green	12-13	85-90	4-5
Red ripe	5-6	85-90	2
Turnip	0	90-95	8-16
Watermelon	12-15	80-90	2
Yam	16-20	60-70	3-5

Exercise No. 3

Demonstration of chilling and freezing injury in fruits and vegetables

Chilling injury typically results from "exposure of susceptible produce, especially that of tropical or sub-tropical origin, to temperatures below 10- 15 C".

However, the critical temperature at which chilling injury occurs varies among commodities. Chilling injury is completely different to freezing injury (which results when ice crystals form in plant tissues at temperatures below their freezing point). Both susceptibility and symptoms of chilling injury are product and even cultivar-specific. Moreover, the same commodity grown in different areas may behave differently in response to similar temperature conditions.

Symptoms of Chilling Injury

1. Skin pitting: is a common chilling injury symptom that is due to collapse of cells beneath the surface. The pits are often discoloured. High rates of water loss from damaged areas may occur, which accentuates the extent of pitting.

2. Browning or blackening of flesh tissues: is another common feature of chilling injury (e.g. avocado; Chilling-induced browning in fruit typically appears first around the vascular (transport) strands. Browning can result from the action of the polyphenoloxidase (PPO) enzyme on phenolic compounds released from the vacuole during chilling, but this mechanism has not been proven in all cases.

3. Water-soaking: in leafy vegetables and some fruits (e.g. papaya)

4. De-greening of citrus fruit is slowed by even mild chilling.

5. Fruit that has been picked immature may fail to ripen or ripen unevenly or slowly after chilling (e.g. tomato).

6. Development of off-flavour or odour (low O_2 levels)

7. Rotting: chilling injury causes the release of metabolities (e.g. amino acids, sugars) and mineral salts from cells. Leakage of metabolites and ions, together with degradation of cell membranes, provides substrates for growth of pathogenic organisms, especially fungi. Such pathogens are often present as latent infections or may contaminate produce during harvesting and postharvest operation. Thus, rots is another common symptom of chilling injury, particularly upon removal from low-temperature storage. Symptoms of chilling injury normally occur while the produce is at low temperature. However, they sometimes chilling injury appear when the produce is removed to a higher temperature and deterioration may then be quite rapid, often within a matter of hours.

Chilling injury symptoms of some fruits

Produce	**Lowest safe storage temperature (oC)**	**Symptoms**
Avocado	5-12	Pitting, browning of pulp and vascular strands
Banana	12	Brown streaking on skin
Cucumber	7	Dark-coloured, water-soaked areas
Eggplant	7	Surface scald
Lemon	10	Pitting of flavedo, membrane staining, red blotches
Lime	7	Pitting
Mango	12-13	Dull skin, brown areas
Melon	7-10	Pitting, surface rots
Papaya	7-15	Pitting, water-soaked areas
Pineapple	6-15	Brown or black flesh
Tomato	10-12	Pitting, Alternaria rots

Management of Chilling Injury

i. Maintaining critical temperature - The safest way to manage chilling injury is to determine the critical temperature for its development in a particular produce and then not expose the commodity to temperatures below that critical temperature (Eg. Safe storage temperature for apple is 0-2$_0$C and care should to taken to not to store apple below this critical temperature to avoid chilling injury). However, it has been found that exposure for a short period to chilling temperatures with subsequent storage at higher temperatures may prevent the development of injury. This conditioning process has been effective in managing

- Black heart in pineapple
- Woolliness in peach
- Flesh browning in plum.

ii. MAS - Modified atmosphere storage may also reduce chilling injury in some commodities.

iii. Maintaining high RH - both in storage at low temperature and after storage can minimize expression of chilling injury symptoms, particularly pitting (e.g. film-wrapped cucumbers).

Exercise No. 4

Extraction and preservation of pulps and juices

Preparation of Fruit Juice

Material Required: Kagzi lime fruits, wire basket, muslin cloth. Lemon squeezer, s. s. knife crown corking machine etc.

Procedure :-

1) **Selection of fruit :** Select fully ripe sound fruits.
2) **Preparation of fruits :** wash the fruit thoroughly under a spray of cold water. Put the fruit in wire basket. Dip the wire basket in boiling waste for three minute take out the basket from boiling water and plug them into cold water. Cut the fruit into two half with sharp stainless steel knife.
3) **Extraction of juice :** Extract the juice with lime squeezer strain the juice with course muslin cloth.
4) **Sedimentation :** Keep the juice in deep bottles for sedimentation for a week.
5) **Decantation :** Decant off the supertant juice and fill into sterilized crown caps bottle leaving head space of its 1.5 cm at the top.
6) **Pasteurization :** Keep the bottles on the false bottle of a pan containing boiling water. Pasteurize the product at 170^0 f half an hr.
7) **Sealing –** Allow the bottle to cool wipe them label and store in cool and dry place.

Important Notes :-

1) Juice should be pure and 100%
2) The above method is by heating white the juice can be preserved without heating i.e. by adding chemical preservatives like kms (350 ppm) Benzoic acid (600 ppm)
3) Both acidic fruits can used for bottling of juice or canning of juice
   a. Acidic fruit : Orange, Lemon, Lime, Phalsa
   b. Non Acidic Fruit : Grapes Pamagrant, Mulberry Jamun, Mango.

Preservation of Juices: Fruit juices, RTS and nectars are preserved by pasteurization or by using chemical preservatives. Squashes, crushes, syrups and cordials are preserved by adding chemical preservative like potassium metabisulphite or sodium benzoate.

1. Pasteurization: Preservation of fruit juices by application of heat is the most common method. Pasteurization is a process in which juice is heated to 1000C or slightly below for a sufficient time to inactivate/kill the microorganisms, which cause spoilage. Usually the fruit juices are pasteurized between 75 and 880C with times ranging from 30 sec to 30 min depending on the type of heating system, the nature of the juice and the size of the container. Pasteurization can be performed either by heating at low temperature for a long time (LTLT) or heating at high temperature for short time (HTST).

2. Aseptic processing and packaging of fruit juices: Aseptic processing and packaging is defined as the process in which a commercially sterile product is packed into pre-sterilized container in a sterile environment. The system make use of high temperature short time (HTST) sterilization in the temperature range of 90-110oC for acid products (pH<4.6) and ultra high temperature (UHT) sterilization 121oC and above for low acid foods (pH>4.6). The commercial aseptic sterilization process takes place in a continuous, closed system. Aseptic processing mayproduce products with better retention of nutrients and excellent sensory quality. Apple, mango, litchi, pineapple drinks etc. in tetra pack are processed commercially using aseptic processing and packaging system.

3. Preservation with chemical: Fruit juices, pulps, squash, cordial, syrup, RTS drinks etc, are preserved with chemical preservatives. Fruit juice and pulps in bulk are preserved with chemical preservatives. Two chemical preservatives most commonly used in preservation of fruit and vegetable products are

(i) Benzoic acid (benzoates)

(ii) Sulphur dioxide (Sulphites).

i) Benzoic acid: Benzoic acid is the effective agent but sparingly soluble in water, thus its sodium salt, which is water soluble, is generally used. Benzoic acid is more effective against yeast as compared to moulds. However, it does not stop lactic acid and acetic acid fermentation. The quantity of sodium benzoate required depends on the nature of the juice, its acidity and type of microbial infection.

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ii) Sulphur dioxide: Potassium meta-bi-sulphite (K2O2SO2 or K2S2O2) is commonly used as a source of sulphur dioxide. On addition to fruit juice or beverage it reacts with acid of the juice and form potassium salt and sulphur dioxide, which is liberated and form sulphurous acid with the water of the juice. Sulphur dioxide is more effective against mould spores and bacteria than yeast and also inhibits enzymes etc. It acts as antioxidant and bleaching agent thus help in the retention of ascorbic acid, carotene and other oxidisable compounds. It also retards non enzymatic browning or discoloration of the product. Its effectiveness depends on the acidity, pH, temperature and other substances present in the fruit juice.

4. Preservation by sugar: Fruit juice containing 66% sugar generally does not ferment. Fruit syrup or sharbats with high total solids (65% and above) have a very low water activity hence micro-organism do not grow. The sugar acts as a preservative by osmosis and does not support the growth of micro-organism. However, the growth of mould and yeast can occur on the surface of jams or jellies which need to be protected by using airtight packing or covering the product with molten paraffin wax.

5. Preservation by carbonation: Carbonation is a process of mixing carbon dioxide under pressure with water, juice or beverages so that the product when served; gives off gas in fine bubbles and has the characteristics taste. Carbonated beverages are generally bottled with carbon dioxide content ranging from 1 to 8 g/litre.

Assignment:

1) Prepare the flow chart for the extraction of aonla pulp
2) Prepare the flow chart for the extraction of pomegranate juice

Exercise No.5

Preparation of Jam

Definition :

Jam is a product made by boiling fruit pulp with sufficient sugar to a reasonably thick consistency, firm enough to hold the fruit tissue in position.

Jam may be made from a single fruit or form a combination of two or more fruit. Pectin present in the fruit give it a good set, high conc. of sugar facilities preservation Apple, Pear, Apricoat, Loquat, Tomato, Carrot, Grapes, Papaya, Sapota, Karonda, Mango, Strawberry and Muskmelon are used in the preparation of Jam

FPO specification:-

Any Jam prepared should have minimum 68% T.S.S. (w/w) and min 45% prepared fruit in final product (w/w)

Material required: - Fruit or veg stainless steel knife, Steel vessels, spoon, sugar, citric acid, Thermometer, hand refractometer etc.

Procedure:

1. **Selection of fruits: -** Fully ripe fruit having good colour and flavor are selected. If the fruit are firm tough and unripe allow it to stand for a day or two develop characteristics flavor and sweetness.
2. **Preparation of fruits:** The selected fruit are washed thoroughly in fresh water leaves stalk and other undesirable portion is removed peel the fruit and removes any stone and cores.

   The fruit are cut into small pieces. If the fruit is tough and hard, boil it with small quantity of water to soften it.
3. **Addition of sugar and Acid:** The proportion of sugar to fruit depend upon variety of fruit and its ripeness. Generally for sour fruit add equal quantity of sugar by wt of the pulp, while to sweet fruit add only ¾ sugar to the weight at the pulp.

   According to type of fruit add citiric acid @ 1.5 to 3 g 1Kg of fruit (acidity of Jam should be in between 0.5 – 0.6%)

4. **Mixing :** Mix the ingredient thoroughly and allow the mixture to stand for ½ to 1 hr so that sugar dissolved in the juice released from the fruit.
5. **Boiling :** Boiling it desirable in order to cause intimated mixing of the fruit pulp and the sugar and to partially concentrate the product be evaporation of excess moisture.

   Cool the mixture slowly with occasionally stirring and crushing till the temperature reaches 105.5^0c at sea level or till the cooking mass approaches the desire consistency for every 150 m size in the attitude a decrease of 0.6^0c should be allowed in the cooking temperature of 105^0c.
6. *End point :*

   1. Temp test : Boil the mass till it reaches the require temperature at the particular altitude. Once this temp is reaches boiling can be stopped.

   2. **Sheet test :** When mass has been boiling for sometimes and has because sufficiently thick in consistency dip a spoon into it and let the product run off the side of the spoon.

   If on cooling the product fall in the form of a sheet instead of flowing readily in a single stream, It means that the end point has been reached.
7. **Filling and sealing :** Fill the hot Jam into clean dry jar or can, placed on an insulating material like a wooden board or a thick pad of cloth (for preventing the brakeage in the case of glass jar) close the filled container without only delay.
8. **Cooling :** Invert the container for about 5 min to sterilized the lid and allow it to cool.
9. **Labeling and storage:** The filled containers are labeled according to specification like kind of product. Home of manufacture date of manufacture net weight of product.

   The labeled containers are stored in cool and dry place.

Assignment:

Prepare the flow chart for the preparation of papaya jam.

Exercise No.6

Preparation of Jelly

Definition: A jelly is a product prepared by boiling a clear strained solution of pectin containing fruit extract free from pulp by adding sugar and citric acid and concentrating to such consistency that gelatinization takes place on cooling.

FPO specification:-

Any Jelly prepared should have minimum 68% T.S.S. (w/w) and min 45% prepared fruit in final product (w/w)

Material required :- Fruits or vegetables, stainless steel knife, spoon, sugar, citric acid, thermometer, jelmeter, muslin cloth, hand refractometer, menthol etc.

Procedure :

1. **Selection of fruit: - The** fruit should be sufficiently ripe but not over ripe and they should have good flavor slightly under ripe fruit yield more pectin than over ripe fruit does because as the fruit ripen the pectin present in it decomposed into pectin acid which does not form a jelly with acid and sugar in practice mixture of under ripe and ripe fruit is used.
2. **Preparation of fruits:** Fruits are washed thoroughly with water remove any adhering dirt. Peeling is done if necessary and then fruit are cut into thin slices so that the acid and pectin in them can be extracted easily.
3. **Extraction of pectin: - Sufficient** quantity of water is added into the fruit slices. The mixture is boiled for half an hour with occasional stirring to avoid charring in the bottom. According to type of fruit citric acid is added at the rate of 1-3 gm per litre of juice. After extraction of pectin, extract should be filtered through the four fold muslin cloth.
4. *Test of pectin :*

   1. Alcohol test: One tea spoon full strained extract is taken in beaker and cooled and 3 teaspoon full of methyl spirit which are poured gently down the side of beaker which is rotated for mixing and allowed to stand for few minute.

a) If extract rich in pectin a single transparent lump or clot well form an equal amount of sugar be in to be added to the extract for reparation of jelly.

b) The extract contain moderate amount of pectin the clot will be less firm and fragment three fourth amount of sugar is to be added.

c) If extract is poor in pectin, numerous small granular cloths will be seen one half the amount of sugar is added.

2. Jelmeter test : The Jelmeter works on the principle of viscosity. First the bottom of the jelmeter tube is closed with little finger. The soloution must be strained through a muslin cloth to get rid of all solid particles and to avoid choking of Jelmeter. The strained extract is poured into jelmeter, till it is filled to the brim. Then the finger is removed from the bottom end and extract is allowed to flow or driple for extractly one minute at the end of which the finger is replaced. The reading of the level of extract in the jelmeter indicate how many parts of sugar are to be added to one part of juice. If the extract completely fall down within a minute, it indicates poor pectin content and such extract needs further boiling until required pectin strength is attained in the extract. To get accurate results, the temperature of the solution should be in the range of 21^0 to 38^0C.

5. **Addition of sugar:** The quantity of sugar to be added depend on the pectin strength of the extract according to alcohol or jelmeter test the requisite quantity of sugar is added into the extract.
6. **Cooking and mixture :** The mixture is boiled till 105.5^0c (at M.S.L.) temperature is reaches. The temp to which the jelly is to be cooked decrease by and 0.6^0c for every 150 m rise in sea level and mixture is looked at corresponding temp at the place during cooking care is taken to prevent charring of the mixture in the bottom by regular stirring of the mixture.
7. *Determining the end point :*

1. Temperature test: When the mixture is boiled at the specified temperature for particular the cooking is stopped.

2. Sheet test: When the jelly is ready it fall down in the form of sheet when tickled down from a spoon. If it falls down in the form of drop, cooking is further continued. Once the end point is reaches boiling should be immediately stopped.

8. **Filling and sealing:** The jelly is allowed to stand for a while and then scum is removed.

   The clear jelly is filled into sterilized jelly bottle leaving 1/3 inch and sealed air tight. If this provision is not available, paraffin wax sealing is done. The wax is melted and poured over the cooled jelly forming a layer of 0.1 cm. This prevents the microbial growth on the surface of jelly.

9. **Labeling and storage :** The sealed bottles are labeled giving the specification as required.

   The labeled bottle as stored in cool and dry places.

IMPORTANT HINTS

1. Final product should contain minimum of 45% fruit
2. Total soluble solids should not be less than 65%.
3. Add artificial pectin if fruits are poor in pectin.
4. Add citric acid in fruits of low acidity.
5. Permitted colours and preservatives can be added if necessary.
6. Good jelly should be gelatinous, clear, sparkling, transparent and of an attractive colour.
7. Jelly should not be sticky, syrupy, or gummy.
8. Good jelly should retain original flavor and aroma.
9. When cut it should retain its shape and show clean cut surface.

Common difficulties arise in jelly making,

1. Failure of jelly to set - it is due to,
a) Lack of acid and pectin b) Addition of to much sugar c) Cooking below and beyond end point d) Slow cooking for long time.

2. Cloudy or foggy jelly -due to, a) Improper clarification of extract. b) Use of immature fruits. c) Overcooking. d) Overcooling. e) Faulty pouring into container. f) Non removal scum

3. Formation of crystals is due to addition of excess sugar

4. Synerisis or weeping jelly- it is sudden erudition of fluid from jelly it is due to
a) Excess of acid. b) Too low concentration of sugar. c) Insufficient pectin

5. Fermentation - due to bacteria and mould etc.

Assignment:
Prepare the flow chart for the preparation of wood apple/guava jelly.

Exercise No.7

Preparation of RTS and Nectar

Ready to serve (RTS):

This is a type of fruit beverage which contains at least 10% fruit juice (for lime drink 5% juice) and not less than 10% total soluble solids. The acidity in these drinks shall not exceed 3.5% as citric acid. RTS beverages are preserved by using preservatives not exceeding 70 ppm SO2 or 120 ppm benzoic acid. It is not diluted before serving hence it is known as ready to serve drink for example mango drink, guava drink, pineapple drink etc.

Papaya RTS

Ripe fruits → Washing → Peeling → Cutting into halves → Seed removal → Passing through pulper → Pulp → Mixing with strained syrup solution (Sugar + Water acid, heated just to dissolve) Homogenisation → Bottling → crown corking → Crown corking → Pasteurization (about 90^{o}C for 25 min) – Cooling → Storage.

Sr. No.	Fruit	Juice/Pulp	Quantity of water required
1	Bael;	10	Quantity of finished products – Quantity of juice (litre) + sugar (kg) + acid (kg) used.
2	Lemon/Lime	10	
3	Guava	10	
4	Aonla (blend)	Aonla pulp 10 Lime juice 2 Ginger juice 1	
5	Mango	10	
6	Ginger	2.5	

Nectar:

This type of fruit beverage contains at least 20% fruit juice or pulp and 15% total soluble solids and is preserved by heat processing. The acidity in fruit nectars shall not exceed 1.5% as citric acid. No class II preservative like SO2 or benzoic acid is permitted in fruit nectar as per Indian Food Laws. It is not diluted before serving.

Assignment:

Prepare the flow chart for the preparation of RTS.

Exercise No.8

Preparation of Squash and Syrup

Preparation of Orange Squash

Squash : This is a strained juice containing moderate quantities of fruit pulp to which cane sugar is added for sweetening. it containing at least 25 per cent fruit juice or pulp and and 40 to 50 per cent TSS, 1 per cent acidity and 350 ppm SO_2.

Material: fruits or Juice, sugar, water, bottles, crown corking machine.

Procedure:

1. Select the fully ripe sound fruits, free form blemishes.
2. Wash them thoroughly in cold water.
3. Trim or peel out the fruits and cut them into pieces
4. Extract the juice as per procedure and strain through a coarse muslin cloth.
5. Measure the juice and sugar according to following recipe.
6. Prepare the syrup by mixing sugar water and acid and heat it just to dissolve.
8. Strain the syrup and then mix it with juice
9. Add the preservative mentioned in the recipe
10. Pour the squash into previously sterilized bottles leaving head space of nearly 1.5 cm. and cap the bottles with crown cork bottles
11. Pasteurize product at 85^{o}C for half an hour. Label, store in cool and dry place.

Squashes can be prepared according to following recipe

Sr. No.	Fruit	Ingredient for one litre pulp/juice			
		Sugar (Kg)	Water (lit.)	Citric acid (g)	Preservative (g)
1	Orange*	1.75	1.0	20	2.5 KMS
2	Mango	1.75	1.0	20	2.5 KMS
3	Lime, Lemon	2.00	1.0	--	2.5 KMS
4	Bael	1.80	1.0	25	2.5 KMS
5	Pineapple	1.75	1.0	20	1.9 KMS
6	Guava	1.80	1.0	20	2.0 KMS
7	Papaya	1.80	1.0	25	2.5 KMS
8	Karonda	1.80	1.0	5	4.0 SB
9	Jamun	1.80	1.0	15	3.0 SB
10	Water melon	0.50	.25	10	1.5 SB

KMS= Potassium metabisulphite SB= Sodium benzoate

F.P.O Specifications: a) T.S.S – 40% b) Juice – 25% c) Acidity – 1.0%

Preparation of syrup

Definition : It is a type of fruit beverage which contain at least 25%. Fruit juice or pulp and in 65% total soluble solids. It also contain 1.3 to 1.5 % acid is diluted before serving.

FPO Specifications :

The prepared syrup should have min 65% TSS (w/w) and min 25% (w/w) fruit juice.

Material required :- Ripe lemon fruit, steel vessel, muslin cloth, sugar, citric acid, salt, potassium metabisuphite, basket press, hand refractometer.

Receipe :-

Clear Juice	:	1 kg	Citric Acid	:	24 gms
sugar	:	2 kg	Water	:	0.50 lit
Pottasium metabisulphite	:	2 gms			

Procedure :

1. Select fruits, which are fully developed and free from blemishes.

2. Wash the material thoroughly.

3. Extract the juice.

4. Strain the juice.

5. For one kilogram of juice prepare 3 kg sugar syrup of 70 ° Brix by dissolving 2 kg sugar in 900 gram of water. Strain it and add 50 gram of citric acid.

6. Mix the juice to hot syrup

7. Fill the product in previously sterilized bottles.

8. Keep the bottles in the boiling water for half an hour and seal them when hot.

9. Allow the bottles to cool and label them.

10. Store the bottle in cool and dry place.

Assignment:

1) Prepare the flow chart for the preparation of orange squash.
2) Prepare the flow chart for the preparation of aonla syrup.

Exercise No.9

Preparation of osmotically dried products

Osmotic drying is based on removal of moisture from a fruit pieces by placing them in contact with granular sugar or a concentrated sugar solution.

The fruit which are highly acidic and have sensitive aroma can be dried by using osmotic dehydration. In this method the fruits after preliminary treatment are placed in hypertonic solution of 70^0B sugar syrup and kept for 4 hrs to overnight. During this period, the water oozes out in syrup due to osmosis. About 50% of moisture from the fruit is removed in can process. The fruits are then drained from the syrup, rinsed and further dried in hot air drier to desired moisture content. During osmotic drying, acid from the fruit oozes out in the syrup while some sugar enters in the fruit thus the final product attains the required sugar acid balance. Apricots, grapes, apple etc. can be dried by using osmotic drying.

Drying of Fruits and Vegetables:

1. Raisin: - Rasins are the second most important product prepared from grape berries, wine being the first. The quality of raisin depends on the size of berries, the uniformity and brilliance of the berry colour, the condition of the berry surface, the texture of the skin, pulp in the berry, moisture content, chemical composition and presence of decay, mould, yeast and foreign matter. Based on the method of preparation and variety of grape used for raisin making, they are called natural, sultana, golden bleached, sulphur bleached, black corianth and valencians.

a) Predrying treatment :

Grapes are immersed in an alkaline solution prior to drying. Dipping the berries facilitates drying by farming cracks in skin. A sodium hydroxide (0.5% NaOH) is used at a temperature usually ranging from 93 to 100^0c. In Australia and India, cold dip solutions such as potassium carbonate (24%) are used. These dip accelerate moisture loss by causing wax platelets on the grapes skin to dissociate thus facilitating water diffusion. Raisin produced by cold dip process are light in colour. Other researchers have used acid dip (Ascorbic acid & malic acid) instead of sulphuring as a method of obtaining light coloured raisins. However this product would undoubtedly have to be held at reduced temperature to prevent darkening during storage.

B. Sulfuring:

The use of sulphurdioxide (SO_2) is common in food industry. Grape berries are exposed to SO_2 before drying. These can be sulfured by placing them in compartment containing burning sulphur. Recently bolted gas of SO_2 is injected into chamber containing the fruits. The bolted gas systems offers numerous advantage such as better ability to control the quantity of SO_2 absorbed by the fruit, less air pollution and it is cost effective. Duration of sulfuring and concentration of SO_2 depends on size, condition of maturity and cultivar of produce being sulfured. The permissible level of SO_2 in raisins in India is 750 ppm.

Exercise No.10

Preparation of fruit bar and candy

Preparation of Ber candy

Definition : A fruit when impregnated with sugar free from syrup drained and dried is called as candied fruit.

Procedure:

Selection of fruits:-

For the selection of fruit following criteria are applied.

i) Fruit should be riped

ii) Should be free from diseases and blemishes

iii) Remove wrinkled, old fruits which are not fit for consumption

Prelimary preparation:-

i) Wash the fruits carefully in fresh cold water.

ii) With the help of needles make holes on the ber surface.

iii) With the help of cork borer remove the seed from fruit

iv) Keep the ber fruit in boiling water for 2-3 minutes.

Sulphur treatment :-

The prepared fruit are then treated with sulphur fumes for 2 hrs (2 gm sulphur/kg of ber

fruits)

Dipping the fruit in sugar syrup :-

The fruit treated with sulphur are then dipped in 40% sugar syrup (1% citric acid for 4 hrs.)

i) For next 24 hrs. fruit are dipped in sugar syrup of 60% Conc. (1% citric acid

ii) For next 24 hrs. fruit are dipped in sugar syrup of 75% Conc. for 7-8 days.

Washing drying and storage:- The fruit are removed from the syrup and are washed with clean water. The candy thus prepared is dried in sunlight for about 2-3 days. The dried candy is stored in plastic bags carefully. Plastic bags are the stored in cool dry place.

Fruit toffee/bar:

Pulpy fruits like mango, guava, papaya etc can be used for making toffee. It is prepared by using 1 kg fruit pulp, 700 g sugar, 100 g glucose, 150 g skimmed milk powder and appropriate amounts of butter or ghee, essence and colour.

Assignments:

1) Prepare the flow chart for the preparation of ber candy.
2) Prepare the flow chart for the preparation of fruit bar.

Exercise No.11

Preparation of tomato products

The different products prepared from tomato are

1) Tomato juice
2) Tomato puree and paste
3) Tomato sauce/ketchup
4) Tomato chutney
5) Tomato soup
6) Tomato pickle
7) Canned tomatoes

Tomato ketchup :

Tomato ketchup is made by concentrating tomato juice or pulp without seed and piece of skin.

Spices, salt, sugar, vinegar, onion, garlic etc. are added to the extent that the ketchup contain not less than 12% tomato solids and 28% total solids.

FPO specification:

T.S.S. : 25%
Acidity : 1.0%

Receipe :

Tomato pulp	-	1 Kg
Sugar	-	75 g
Salt	-	10 g
Onion (chopped)	-	50 g
Ginger	-	10 g
Garlic	-	5 g
Red chilli powder	-	5 g
Cinnamon, Cardamom (large), Cumin, Black Pepper (powdered)	-	10 g each
Clove (headless)		5 nos.
Vinegar	-	25 ml
Sodium benzoate	-	0.25 g per Kg final product

Procedure:

1. **Selection of fruit: - Select** fully ripe, red tomatoes free from insect and disease, fully ripe tomatoes have characteristics flavor and sweetness.
2. **Preparation of the fruit:** Wash the fruit thoroughly in fresh water.
3. **Extraction of juice:** Cut the stalk end portion with the help of stainless steel knife then cut fruits into small pieces and cook them in steel vessels while cooking press the fruit pieces with wooden mallet and strain through 1 mm mesh stainless steel sieves. Press the pulp thoroughly so as to get the maximum juice.
4. **Addition of spices, sugar, salt and vinegar:** Add 1/3 amount of sugar to the tomato juice. Take all the spices as per recipe and then tie in muslin cloth after making into fine powder and small pieces (onion, garlic clove, cardamom, black pepper, cumin, mace, cinnamon and red chilli powder) keep the bag immersing in the boiling pulp.
5. **Cooking :** Cook the pulp to thick consistency by till it reduces to $1/3^{rd}$ of its original volume remove the muslin bag and squeeze it to remove extract of spice. Add vinegar, salt and remaining quantity of sugar. Heat the mass for few minute to dissolve the ingredient and the final volume of the product is reduced to $1/3^{rd}$ of its original volume.
6. **Determining the end point :**
    1. **Volume test :** The end product must be 1/3 the original pulp
    2. **T.S.S.:** T.S.S. the final product should have minimum of 28% T.S.S.
    3. **Blotting paper test:** Put a drop of mass over a blotting paper. If all the free water in the mass has evaporated and only a red mark remain on the blotting paper stop further boiling.
7. **Addition of chemical preservatives :** To the small quantity of finished product add the chemical preservatives sodium benzoate at the rate of 750 mg/kg of the finished product and mix thoroughly.

8. **Filling and sealing :** Pour the finished product into medium sized pre-sterilized bottle leaving ½'' head space and then air tight with crown cap.
9. **Pasteurization :** The sealed bottles are pasteurized in boiling water for 30 min. Keeping them on a false bottom to avoid bumping while pasteurization.
10. **Labeling and storage :** Label and store at cool and dry place.

PREPARATION OF PUREE AND PASTE

Tomato pulp without skin or seeds, with or without added salt, and containing not less than 9.0% of salt free tomato solids, is known as medium tomato puree'. It can be concentrated further to heavy tomato puree which contains not less than 12.0% solids. If this is further concentrated so that it contains not less than 25% tomato solids, it is known as tomato paste, on further concentration to 33% or more of solids it is called concentrated tomato paste.

Tomato pulp is prepared from ripe tomatoes in the same manner as tomato juice. Cooking for concentration of the pulp can be done either in an open cooker or a vacuum pan. In the former most of the vitamins are destroyed and the product become brown. On the other hand, use of vacuum pans, which are extensive, help to preserve the nutrients, and also reduce the browning to a great extent. In vacuum pans the juice is boiled at about 71^{o}C only. While cooking in an open cooker, a little butter or edible oil is added to prevent foaming, burning and sticking.

After cooking, the total solids content of the juice is higher than required, more juice is added to lower it, if it is lower, cooking is continued till the desired concentration is reached. Theendpoint of cooking puree and paste can be determined either with a hand refractometer or by measuring the volume.

Process

Tomato juice (strained) → Cooking to desired consistency (open cooker / vacuum pan) → Judging of endpoint for puree (or) paste → Filling hot into bottles or cans (82-88^{o}C) → Sterilization in boiling water for 20 min. →Cooling → Storage at ambient temperature.

Assignments:

1) Prepare the flow chart for the preparation of tomato ketchup.

Exercise No.12

Preparation of canned products

Canning:

The process of sealing foodstuffs hermetically in containers and sterilization them by heat for long storage is called as canning.

Principle:

Destruction of spoilage organisms within the sealed container by means of heat.

Steps involved in canning of fruits and vegetables

Preparation of fruit and vegetables: Preparation of food commodity for canning consists of washing, sorting, grading, peeling, halving, blanching etc.

1) Washing: Fruit and vegetables are generally washed with water to remove dust, dirt and adhering surface micro-flora. Fruits like peach, apricot etc are lye peeled so not washed before peeling. On the other hand, washing after peeling removes vitamins and minerals and should be discouraged. Different methods of washing include soaking or agitating in water, washing with cold or hot water sprays etc.

2) Sorting and grading: Sorting and grading ensures the removal of inferior or damaged commodity. For sorting, inspection belt can be used, in addition to trained personnel who detect poor quality produce unsuitable for canning.

3) Peeling, coring and pitting: These are the primary unit operations for preparing fruit and vegetables for canning. Depending upon the type of commodity, peeling and coring methods are selected such as (1) by hand or knife (2) by machine (3) by heat treatment (4) by using lye solution. Cores and pits in fruits like apple, peach, apricot etc are removed by hand or by machine (de-corer).

4) Lye peeling: Lye is an boiling aqueous solution of caustic soda (Sodium hydroxide) or Potassium hydroxide (1-2%) used in conjunction with ample water supply and heat source for peeling. Fruit and vegetables like peaches, nectarines, apricot, sweet orange segments, carrots and sweet potatoes are peeled by dipping them in boiling caustic soda (1-2%) for 1-2 minutes (depending upon the strength of lye, temperature/maturity and nature of fruit or vegetable) followed by dipping in cold water. The hot lye loosens the skin from the flesh underneath which is removed by gentle rubbing of fruit by hand. The fruit can also be dipped in a dilute solution of hydrochloric acid or citric acid for few seconds to neutralize the alkali. The method is very quick and efficient to reduce wastage and peeling cost. The effectiveness of lye peeling depends upon lye concentration and temperature, product holding time and agitation.

Cutting/halving/ slicing: After peeling, the fruits are halved or cored either manually or mechanically. However, peeled fruit should always be kept submerged in either water, containing 1-2 % salt solution or acid to avoid enzymatic browning. Peaches, apricot, pears, tomatoes etc are peeled before canning. However, the fruits which are canned retain better nutrients as compared to peeled fruits.

5) **Blanching:** Treatment of fruit and vegetables with boiling water or steam for short periods followed by immediate cooling prior to canning is called blanching. The basic objectives of blanching are as under:

- To inactivate enzymes
- To clean the product initially to decrease the microbial load and to preheat the product before processing
- To soften the tissue to facilitate compact packing in the can
- To expel intracellular gases in the raw fruit to prevent excessive pressure built up in the container.
- To allow improved heat transfer during heat processing
- To ensure development of vacuum in the can and to reduce internal can corrosion.

Blanching is carried out either by hot water or using live steam. Water blanching is generally of the immersion type or spray type as the product moves on a conveyer.

Only soft water should be used for blanching as hard water toughens the tissue and destroys the natural texture.

Prevention of browning: Some fruits which cannot be blanched due to their delicate tissue structure are treated with some chemicals to prevent oxidative browning, occurring due to exposure to oxygen during peeling and slicing. Oxidative browning is caused by action of oxidase enzyme with catechol and tannins and is common in peach, apple, potato, mushroom, cherry, apricot, grapes and persimmon. Pineapple, tomato and melons are however not prone to browning.

6) Syruping: A solution of sugar in water is called a syrup. Normally sucose syrup is used in canning. Syrup is added to improve the flavor and to serve as a heat transfer medium for facilitating processing. Syruping is done only for fruits. The syrup should be filled at about 79 to 82^0C, leaving a head space of 0.3 to 0.5 cm.

7) Brining: A solution of salt in water is called brine. Only vegetables are brined. Common salt of good quality free from iron should be used. Hot brine of 1 to 3 per cent concentration is used for covering vegetables and is filled at 79 to 82^0C, leaving a head space of 0.3 to 0.5 cm.

8) Filling in cans: Tin cans are washed in hot water or in steam jet to remove any adhering dust or foreign matter. The cans are then sterilized by dipping in hot water tank or the cans are passed through a steam sterilizing tunnel before use. Generally plain cans are used however, for coloured fruits like plums, black grapes; strawberries etc lacquered cans are employed. The fruit and vegetable either slices, halves or whole are filled into the cans keeping in view the declared drain weight.

9) Exhausting: The process of removal of air from cans is called exhausting.

10) Heat processing: The cans after sealing are immediately transferred to the heating retorts to achieve sterilization of contents. Heat processing consists of heating cans to a predetermined time and temperature of heating to eliminate all possibilities of microbial spoilage. Over cooking should be avoided as it spoils the texture, flavour and appearance of the product. Generally all fruits and acid vegetables can be processed satisfactorily in boiling water (100^oC) as the presence of acid retards the growth of bacteria and their spores.

11) Cooling and storage: After processing, the cans are cooled rapidly to about 39^0C to stop the cooking process and to prevent stack-burning. Cooling is done by dipping the cans in cold water.

After labelling, the cans, they are packed in strong wooden cases or CFB cartons and stored in a cool and dry place.

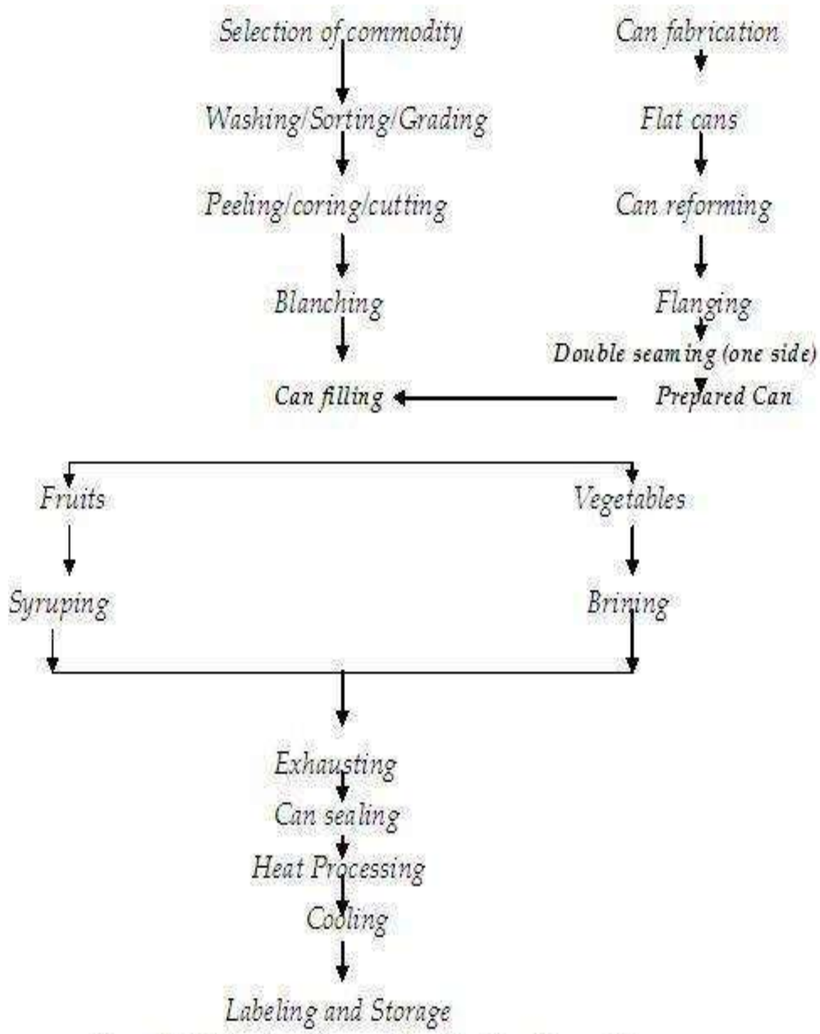


Figure 7.1: Flow sheet for canning of fruits and vegetables

Exercise No.13

Layout and planning of pack house

Need of packhouse

After harvest, fruits and vegetables need to be prepared for sale. This can be undertaken on the farm or at the level of retail, wholesale or supermarket chain. Regardless of the destination, preparation for the fresh market comprises four basic key operations:

1. Removal of unmarketable material,
2. Sorting by maturity and/or size,
3. Grading,
4. Packaging.

Any working arrangement that reduces handling will lead to lower costs and will assist in reducing quality losses. Market preparation is therefore preferably carried out in the field. However, this is only really possible with tender or perishable products or small volumes for nearby markets. Products need to be transported to a packinghouse or packing shed in the following cases: for large operations, distant or demanding markets or products requiring special operations like washing, brushing, waxing, controlled ripening, refrigeration, storage or any specific type of treatment or packaging.

These two systems (field vs. packinghouse preparation) are not mutually exclusive. In many cases part field preparation is completed later in the packing shed. Because it is a waste of time and money to handle unmarketable units, primary selection of fruits and vegetables is always carried out in the field. In this way products with severe defects, injuries or diseases are removed.

General considerations about design

A packinghouse needs to be located close to the production area and within easy access to main roads or highways. It also needs to have one entrance to facilitate and control supply and delivery. Moreover, it needs to be large enough for future expansion or additional new facilities. Sufficient space outside is also required to avoid congestion of vehicles entering and leaving. Buildings should be designed to ensure sufficient shade during most of the day in the loading and unloading areas. They also need good ventilation in summer and protection in winter.

Packinghouses are usually built with cheap materials. However, it is important to create a comfortable environment both for produce and workers. This is because product exposed to unfavorable conditions can lead to rapid deterioration in quality. Also, uncomfortable working conditions for staff can lead to unnecessary rough handling.

A packinghouse should have adequate room for easy circulation with ramps to facilitate loading and unloading. Doors and spaces should be sufficiently large to allow the use of forklifts.The reception area should be large enough to hold product equivalent to one working day. The main reason for this is to keep the packinghouse in operation in the event of an interruption in the flow of product from the field (rain, machine breakdown, etc).

Electricity is critical for equipment, refrigeration and particularly lighting. Because packhouses usually work extended hours or even continuously during harvest time, lighting (both, intensity and quality) is critical in identifying defects on inspection tables. Lights should be below eye level to prevent glare and eyestrain (Figure 25). Light intensity should be around 2 000-2 500 lx for light coloured products but 4 000-5 000 for darker ones. The working area together with the whole building should have lighting. This is in order to avoid the contrasts caused by shaded areas, resulting in temporary blindness when the eyes are raised. Dull colours and non-glossy surfaces are a requirement for equipment, conveyor belts and outfits. In this way, defects are not masked because of the reflection of light. It also helps to reduce eye fatigue.

A good supply of water is important for washing product, trucks, bins and equipment, as well as for dumping. In some cases it may also be necessary for hydro cooling. Provision of an adequate waste water disposal system is as important as a good source.

Administration offices should be located on clean and quiet areas and if possible elevated. This is so that the entire operation is visible. Packinghouses should have facilities or laboratories for quality analysis.

General considerations about operations

- Reception
- Removal of rejects
- Sizing
- Grading
- Waxing
- Degreening
- Controlled ripening
- Pest and disease control
- Temperature treatment.

Exercise No.14

Layout and planning of processing unit

For setting up fruit processing plant following cost and non cost factors affecting location of the plant are taken into consideration.

• Cost factors include raw material cost, transportations cost, cost of land, building and machinery, utilities cost, taxes and insurance costs.

• Non-cost factors consists of wages, salaries and incentives, market potential, community attitude, cost regulation, quality of life (school, living, recreation for workers etc) and environmental impact.

Objective:

The main objective for selection of site for processing unit is to minimize the sum of all costs. To minimize the cost, one should think not only the today's costs, but of long term costs as well.

Plant layout :

The advantages of good plant layout are:-

1. Saving in floor space
2. Increased output
3. Fewer production delays
4. Reduced material handling
5. Greater utilization of machine and man power
6. Easier and better supervision
7. Less congestion and confusion
8. Better appearance and more sanitary condition of work areas
9. Reduced risk to health and safety of employees

1) *Selection of Site for fruit processing unit*

The location of unit is a dominant factor in viability (success or failure) of any processing industry. The following factors are considered in the selection of site for processing unit.

- Easy availability of raw material: Fruit and vegetables should be available in adequate quantity in the locality as they are highly perishable and deteriorate in long distance transportation. Other raw material like fuel, sugar, salt, chemicals etc and miscellaneous hand tools such as nuts, bolts, minor machinery parts etc should also be easily available in the locality.
- The site should be well connected with road.
- Proper transport facilities for movement of raw material and finished products.
- Area should have adequate supply of potable water and electricity (preferably three phase connection).
- Environment should be clean and free from debris, dirt, dust etc.
- The processing industry should preferably be well away from other industries to avoid soot, smoke and disagreeable odour.
- Provision for disposal of processing waste.
- Adequate availability of labour.
- The selected site should have scope for future expansion.

2. *Building for processing plant:*

Following points should be kept in mind for establishment of building for the processing plant.

- It may be single storied or multi storied building. Single storeyed building is sufficient for small unit working for short periods during the year. However, for larger processing plants running throughout the year, multistoried construction is desired. It facilities the movement of raw material and finished products.
- Firm flooring to withstand constant use of water and movement of heavy machinery.
- Slope in flooring (2cm per meter) for proper drainage.
- All doors, windows and ventilators should be provided with fine wire gauge to prevent entry of flies, wasps and other insects.
- The roof of the building should be high and well ventilated to provide outlet for vapours and steam.
- The windows should have large glass panels for sky light and artificial lighting.

- Provision for dressing and toilet rooms separately for male and female workers.

3. *Types of plant layout*

The layout of a processing plant can be selected on the basis of either product layout or process layout (Fig 1). Product layout deals with either single fruit or single product such as apple processing in to juice or jam processing line in which only apple product can be handled.

• In product layout, all types of jam, pickle, juice or ketchup can be handled irrespective of fruit.

• In process layout, the machinery dealing with different unit operation is placed separately. For example for extraction of juice, the fruit is washed in washing line, grate in grating machine, pressed in hydraulic press and then juice is filled in filling line and processed in processing line.

Depending upon the size of the unit, the layout can be selected.

4. *Water supply and drainage*

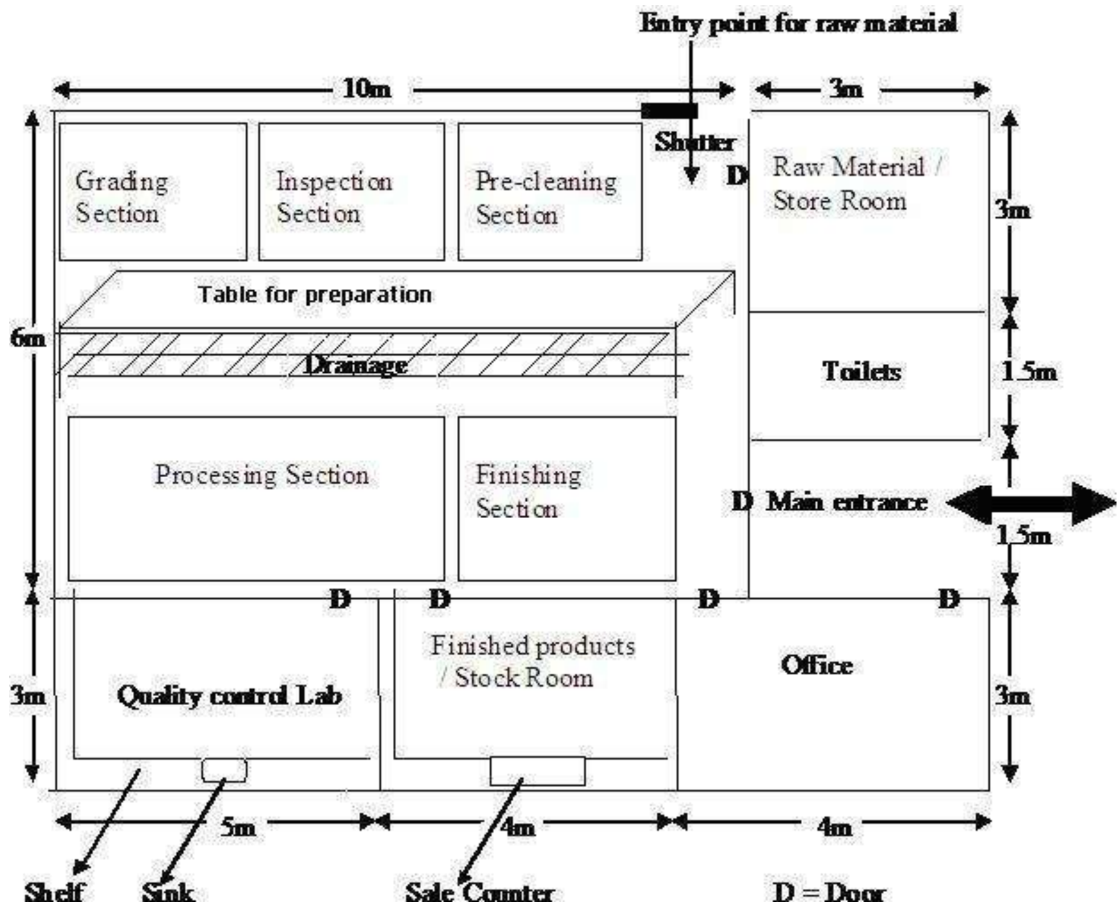
Water of potable nature should be abundant in supply. If water is not of desired quality there is a need for installing water softening plant.

- A large quantity of water is needed for cleaning of fruits and vegetables, making syrup and brine, washing floors and machinery etc.
- Water system should work at sufficiently high pressure so that supplies can be made to different places without any break.
- The water should not be alkaline or very hard, should be free of organic matter.
- Presence of iron and sulphur make the water unsuitable for making syrups and brines.
- Saline water affects the taste of the products and should be avoided.

5. *Categories of fruit processing units*

According to Fruit Products Order (1955) of the Govt. of India, the fruit processing units are categorized as under depending upon the installed capacity and requirement of minimum area for processing (Small scale, home scale, cottage scale, large scale etc.).

Sr.No	Category	Annual Production, tonnes	Minimum manufacturing area required, m^2
1.	Home scale(B)	25	25
2	Cottage scale	10-50	60
3.	Small Scale(A)	50-100	100
4.	Small Scale(B)	100-250	150
5.	Large Scale	250	300



Layout of a processing plant

Exercise No.15

Quality evaluation of products- physico-chemical and sensory

Quality is a measure of the degree of excellence or degree of acceptability by the consumer. It is also defined as the combination of attributes or characteristics of the products that has significance in determining the degree of acceptability of the product to a user. Industry defines quality as the measure of purity, strength, flavour, colour, size, maturity, workmanship or any other distinctive attribute or characteristics of the product. The quality standards of fresh and processed fruit or vegetable products vary with their intended use. For marketing purposes; size, attractiveness, maturity, organoleptic quality and freedom from defects are to be kept in mind. While for processing, physico-chemical attributes of raw material such as presence of soluble solids, development of uniform colour, flavour, juiciness, uniform maturity, tenderness in some vegetables etc are taken into consideration. During processing of fruit or vegetables into value added products; colour, flavour and texture etc also become important.

Methods of quality evaluation

1) Physical methods: These are the quicker methods and require least training for the evaluator. They include visual appearance, colour, texture, consistency, size, shape or some process variables like head space, fill, vacuum, drain weight etc. The colour of the food products can be measured using calorimeter, tintometer or Hunter colour difference meter. While texture can be determined by using texture analyser or firmness of fruit is estimated by penetrometer. On the basis of texture profile, the product can be classified as chewy, grainy, crispy, mealy etc. These methods are called as instrumental methods.

2) Chemical methods: These are the standard analytical methods and are used for quantitative chemical evaluation of nutritive value and quality levels. However, such analytical methods are lengthy, tedious and expensive. For routine analyses quick tests are developed like pH, acidity, TSS, jellification etc.

Attribute	**Method /equipment to be used**
1. Physical test	Vernier calliper
Size	Weighing balance
Weight	Water displacement method
Volume	Specific gravity bottle, pycnometer
Specific gravity	Net weight + Tare weight
Gross weight	Weight of container
Tare weight	Gross weight – Tare weight
Colour	Visual colour chart
Texture	Texture Analyser
Firmness	Penetrometer, Pressure tester
Consistency	Ostwald viscometer
Viscosity	Brookfield viscometer
Head space	Head space gauge
Vaccum/ pressure	Vaccum/ pressure gauge
Can testing	Can tester
2. Chemical test	
TSS	Hand Refractometer
Brine strength	Salometer
Moisture	Oven drying method, infra-red moisture meter
pH	pH meter
Titratable acidity	Alkali titration method
Sugars (Reducing)	2,6 dichloro-phenol- indophenol dye titration method
Sugars(Non-reducing)	Silver nitrate titration using Mohr's method
3. Sensary evaluation	
Colour	Hedonic rating test
Flavour	Numerical scoring test
Body	Ranking test
Overall acceptability	Paired comparison test; Single sample test; Multiple sample test

Sensory evaluation:

After physical, chemical and microbiological examinations have been performed on a finished products with a satisfactory result, the product is considered ready for distribution, but only after its palatability or sensory quality has been assessed. Sensory quality is a combination of different senses of perception which come into play in choosing and eating a food. The principle sensory properties which affect the palatability of food are as follows.

i) Appearance
ii) Texture
iii) Flavour

Although the physical and chemical tests are not adequate to give the required information, human judges, therefore, have to be used. Measurement of the relative palatability of a food is attempted in two ways

i) By obtaining the judgement of experts,
ii) By testing the preferences of a sample of the public for whom the products is intended and is known as market testing.

Exercise No.16

Visit to processing unit

INDEX

Sr. No.	Name of Practical Exercise	Page No.	Date	Sign.
1.	Application of different types of packaging containers for shelf life extension	**1**		
2.	Effect of temperature on shelf life and quality of produce	**4**		
3.	Demonstration of chilling and freezing injury in fruits and vegetables	**8**		
4.	Extraction and preservation of pulps and juices	**10**		
5.	Preparation of jam	**13**		
6.	Preparation of jelly	**15**		
7.	Preparation of RTS and nectar	**18**		
8.	Preparation of squash and syrup	**19**		
9.	Preparation of osmotically dried products	**21**		
10.	Preparation of fruit bar and candy	**23**		
11.	Preparation of Tomato products	**25**		
12	Preparation of canned products	**28**		
13.	Layout and planning of pack house	**32**		
14.	Layout and planning of processing unit	**35**		
15.	Quality evaluation of products- physico-chemical and sensory	**39**		
16.	Visit to processing unit	**42**		

Practical Manual
AGS-605
Management of Beneficial Insects

Table of Contents

Experiment No.	Title	Page No.
1	Identification of Typical Symptoms of Damage by various Phytophagous Insects	1-3
2	Identification of Insect Pests of Vegetables and Their Damage Symptoms	4-9
3	Identification of Insect Pests of Coconut, Turmeric, Betel Vine, Onion, Ginger and Tobacco and Their Damage Symptoms	10-14
4	Identification of Insect Pests of Mango, Cashew and Banana and Their Damage Symptoms	15-18
5	Identification of Insect Pests of Citrus and Sapota and Their Damage Symptoms	19-21
6	Identification of Insect Pests of Grapevine, Pomegranate And Guava and Their Damage Symptoms	22-24
7	Identification of Insect Pests of Flower and Ornamental Plants and Their Damage Symptoms	25-27
8	Study of Different Species of Honey Bees and Bee Hives	28-33
9	Study of Equipment for Handling HoneyBees	34-36
10	Study of Insect Pests And Diseases of Bees	37-39
11	Study of Different Species of Silkworm	40-42
12	Silkworm Rearing House and Equipment	43-45
13	Mulberry Cultivation and Mulberry Varieties	46-48
14	Study on Lac Culture	49-50
15	Lac Host Plants and Methods of Inoculation	51-55

List of Tables

Table No.	Title	Page No.
1.1	Characteristic symptoms of damage caused by different pests	3
2.1	Marks of identification, nature and symptoms of damage caused by insect pests of vegetable crops	4-9
3.1	Marks of identification, nature and symptoms of damage caused by insect pests of Coconut, Turmeric, Betelvine, Onion Ginger and Tobacco	10-14
4.1	Marks of identification, nature and symptoms of damage of Insect Pests of Mango, Cashew and Banana	15-17
5.1	Marks of identification, nature and symptoms of damage of Insect Pests of Citrus and Sapota	19-21
6.1	Marks of identification, nature and symptoms of damage of Insect Pests of Grapevine, Pomegranate And Guava	22-23
7.1	Marks of identification, nature and symptoms of damage of Insect Pests of Flowers and Ornamental Plants	25-27
8.1	Important Honey Bees species	29-30
9.1	Bee keeping Equipment for Handling HoneyBees	34-35
10.1	Symptoms of brood diseases	38
11.1	Recommended Mulberry varieties	40
13.1	Mulberry Cultivation and Mulberry Varieties	48

Ex. No: 1 **Date:**

Identification of Typical Symptoms of Damage by various Phytophagous Insects

Insects inflict injury to plant either directly or indirectly to secure food. Almost all portions of plant *viz.*, roots, stem, bark, leaves, buds, flowers and fruits are attacked. The study of signs/ symptoms exhibited by different parts of the plant due to the damage caused b y the insect pests are known as symptomatology. Based on the nature and symptoms of damage, insects can be classified into different groups as mentioned below:

1. **Stem Borers**
   Larvae enter into the stem/ tillers and feed on internal contents. As a result, damaged part is cut off from the main plant and affected part wilts, dries up and exhibits symptoms like dead heart/ white ear/ bunchy top.
   e.g. Stem Borers of Paddy, Millets, Sugarcane and Brinjal
2. **Shoot Borers**
   Larvae attack tender shoots and bore inside during the vegetative stage of crop growth and cause wilting, drooping of terminal plant part which later dries up.
   e.g. Shoot Borers of Brinjal, Bhendi, Cotton, Castor, Shoot Fly of Sorghum and Black Gram Stem Fly.
3. **Defoliators/ Skeletonizers**
   Larvae feed on the leaves completelyleaving only midrib/ veins or scrape the chlorophyll content of leaves or cause numerous holes.
   e.g. Castor Semilooper, Red Headed Hairy Caterpillar, Bihar Hairy Caterpillar, Snake Gourd Semilooper, Ash Weevils, Tobacco Caterpillar, Brinjal Epilachna Beetle
4. **Leaf Miners**
   Larvae mine leaves/ leaflets between the epidermal layers and feed on greenish matter, resulting in the appearance of translucent white patches/ zig-zag galleries on leaves.
   e.g. Leaf Miners of Citrus, Cashew and Rice Hispa.
5. **Leaf Webbers**
   Larvae web leaves/ leaflets by means of silken threads and feed on the chloroph yll content by remaining within the web. Often faecal pellets/ frass are found within the web.
   e.g. Leaf Webbers on Gingelly, Ground Nut, Sapota, Mango and Cashew Shoot Webber.
6. **Leaf Folders**
   Larvae fold leaves from tip to base/ longitudinally/ margin to margin there b y giving appearance of a fold/ roll.
   e.g. Rice Leaf Folder, Cotton Leaf Folder

7. **Gall Makers**

Larvae feeding inside the stem/ tiller/ leaf/ flower bud, stimulates excessive growth of cells at the affected portion and distorts normal growth. It results in malformation of plant parts, exhibiting gall formation.

e.g. Paddy Gall Midge, Tobacco Stem Borer, Cotton Stem Weevil, Mango Inflorescence Midge, Chilli Midge

8. **Pod/ Capsule Borers/ Boll Worms**

During the reproductive stage of crop, larva enter into the pods, capsules and feed on the seeds/ lint exhibiting symptoms like webbed condition of pods/ bolls or web few pods/ capsules with frass and excreta or holes of different sizes and shapes/ damaged tissues (Chilli)/ lint (Cotton).

e.g. Spotted Pod Borer, Capsule Borers of Castor and Gingelly, Red Gram Pod Fly, Tobacco Caterpillar, Gram Caterpillar, Pink Boll Worm

9. **Fruit Borers**

Larvae enter into the tender fruits and feed on fresh matter/ pulp and plug the larval burrow with excreta. e.g. Fruit Borer of Brinjal/ Bhendi/ Tomato, Mango Stone Weevil, Cashew, Apple and Nut Borer.

10. **Bark Borers**

Larvae remain in a small tunnel at the axils of branches, under the bark, constructing galleries of frassy web on the stem and near bark/ angles of branches and move about, conceal inside the silken gallery and feed on the bark by scraping.

e.g. Bark Eating Caterpillars of Citrus, Mango, Guava, Casuarinas

11. **Tree Borers**

Larvae bore deep into the tree trunk, make the tunnels in zig-zag manner and feed on inner tissues, arresting translocation of sap to top portions of tree, there by the trees exhibit symptoms like yellowing, withering of leaves, drying of twigs or complete drying of tree. Sometimes, gumm y material oozes from the affected portion on the tree trunk. e.g. Tree Borers of Mango, Cashew, Coconut Red Palm Weevil

12. **Root Feeders**

Larvae feed on root/ root nodules or nymphs and adults suck sap form the roots resulting in stunted growth/ poor tillering/ dr ying of plants in isolated patches.

e.g. White Grubs, Termites, Rice Root Weevil and Ragi Root Aphid.

13. **From Fruits**

Holes, plugged with excreta/ forming necrotic patches/ rotting on fruit. e.g. Fruit Flies, Fruit Sucking Moths.

14. **Seed Feeders (Stored Grain Pests)**

Larvae feed on stored seeds either as internal/ external feeders/ by webbing the food particles.

e.g. Rice Weevil, Red Rust Flour Beetle, Rice Moth

15. Sap Feeders

1. **From Grain:** Nymphs and adults suck juice from developing ovaries/ milky grains resulting in the formation of shrivelled/ chaffy grains
   e.g.**,** Rice Gundhi Bug, Sorghum Earhead Bug, Sorghum Midge
2. **From Tender Plant Parts:** Nymphs and adults suck sap from the base of the plant/ leaves/ tender terminal plant parts/ flowers, thereby affect the vigour and growth of the plants. Different insects exhibit different symptoms. In case of severe infestation, sooty mould develops on the plant parts covered with honey dew excreted by insects while feeding.

Table 1.1 Characteristic symptoms of damage caused by different pests

Sl. No.	Symptoms	Example
1	Hopper burn, complete drying of leaves and plants in patches, giving scorched appearance	Paddy Brown Planthopper, White Backed Plant Hopper, Paddy Leafhopper
2	Curling of leaf margins/ mottling/ Necrotic patches	Cotton Leafhopper
3	Upward curling of leaves	Chilli Thrips
4	Downward curling of leaves/ elongation of petioles of older leaves/ reduction in leaf size and clustering at tip of branch/ brittleness	Chilli White Mites
5	Leaf drying from top to bottom	Onion Thrips
6	White/ yellow blotches on upper surface of leaves	Mites on Castor/ Coconut/ Bhendi.
7	Reduced vigour/ sooty mould/ square/ flower drop	Whiteflies on Cotton
8	Yellowing/ crinkling of leaves	Thrips on Ground Nut, Pulses
9	Reduced vigour/ stunted growth/ yellowing/ sooty mould	Aphids

Q. Draw any 8 important horticultural pests with their characteristic symptoms of damage with proper labels.

Ex. No: 2 Date:

Identification of Insect Pests of Vegetables and Their Damage Symptoms

Table 2.1Marks of identification, nature and symptoms of damage caused by insect pests of vegetable crops

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
BRINJAL			
1. **EPILACHNA BEETLE:** *Henosepilachna viginctioctopunctata* Fabricius, Coccinellidae: Coleoptera	**Adult:** An yellow hemispherical beetle with 12-28 black spots on elytra. Head partly concealed by pronotum. **Grub:** Body yellowish broad anteriorly and narrow posteriorly and covered with spiny structures all over.	Both grubs and adults scrape the leaves in characteristic manner and feed (ladder like scrapings). They confine their feeding activity mostly to the lower side of leaves.	
2. **SHOOT AND FRUIT BORER:** *Leucinodes orbonalis* Guenee, Pyralidae: Lepidoptera	**Adult:** White moth with pink brown markings on wings and blackish brown head and thorax. **Caterpillar:** Pinkish with sparingly disturbed hairs arising on warts all over the body.	If infestation occurs during vegetative phase, caterpillars enter into the petiole, midribs and young shots. As a result, the infested shoot wilts and droops. During fruiting stage, caterpillars enter into fruits make holes and feed inside. Initially, the entry hole is so small that it is not visible. Later, fruits bear large circular holes plugged with excreta.	

1	2	3	4
3. BRINJAL STEM BORER: *Euzophera perticella* Rag. Pyralidae: Lepidoptera	**Adult:** Medium sized with greyish brown forewings having transverse lines in the middle and white hind wings. **Caterpillar:** Creamy white in colour.	Caterpillar enters into stem near the axil of leaf/ branch at ground level of the plant. Excreta can be seen coming out of the entry hole. An infested plant wilts and dries up.	
4. MEALY BUG: *Centrococcus insolitus* (G.), Pseudococcidae: Hemiptera	**Adult:** Brownish/pinkish and oval in shape. Body covered with white waxy filamentous material.	Colonies of nymphs and adults suck sap from lower side of leaves, tender shoots and fruit stalks. Infestation results in yellowing and drying of plants. Infested leaves look as if white washed.	
5. BRINJAL MITE: *Tetranychus telarius* L., Tetranychidae: Acarina		Feed on lower surface of leaves by remaining underneath a web in case of red spider mites. Infested leaves curl down become hard and crisp and ultimately shed.	
BHENDI			
1. SHOOT AND FRUIT BORER: *Earias vittella* Fabricius, *E. insulana* Boisduval, Noctuidae: Lepidoptera	**Adult:** Fore wings of *E. vittella* are pale white with a broad greenish transverse band in the middle while those of *E. insulana* are completely green. **Caterpillar:** Brownish white with a dark head and prothoracic shield. Body surface is irregularly spotted and shiny.	Insect first appears on the crop about 6 weeks after sowing and initially damages the tender shoots by boring into them, which results in drooping of shoots. In the later stages, larvae bore into the flower buds and fruits. Larval feeding results in severe shedding of early formed flower buds.	

1	2	3	4
2. LEAFHOPPER: *Amrasca biguttula biguttula* (Ishida), Cicadellidae: Hemiptera	**Adult:** Wedge shaped with two black spots on vertex and a black spot on each forewing. **Nymph:** Greenish varying from less than a millimetre to about 3 mm.	Both nymphs and adults suck sap from leaf tissues. During the process of de-sapping, they inject a toxin into plant tissue, resulting in hopper burn. Infestation results in general mottling accompanied by curling	
CRUCIFERS			
3. DIAMOND BACK MOTH: *Plutella xylostella* Linnaeus, Plutellidae: Lepidoptera	**Adult:** Small gra yish brown with narrow forewings having pale white marking at anal region which form a diamond like patch, when folded. **Caterpillar:** Small greenish with short hairs on body which tapers towards both the ends.	Caterpillars feed on the lower side of leaves and bite holes on leaves. Affected leaves present a withered appearance. In severe case, leaves are skeletonized.	
4. CABBAGE BORER: *Helulla undalis* Fabricius, Pyralidae: Lepidoptera	**Adult:** Small pale brown with grey wavy lines and central elliptical marking on forewings. **Caterpillar:** Brownish with a black head and four longitudinal lines on the body.	Caterpillars web the leaves and bore into stem, stalk or leaf veins. They bore into the cabbage head also and make it unfit for consumption.	
5. CABBAGE LEAF WEBBER: *Crocidolomia pavonana* Zeller, Pyralidae: Lepidoptera	**Adult:** Small with light brownish forewings. **Caterpillar:** Bears red head with brown longitudinal stripes and rows of tubercles on the body.	Caterpillars web the foliage and skeletonize the leaves. Feed on flower heads in case of cabbage and cauliflower. Also feeds on flowers and pods in case of mustard.	

1	2	3	4
CUCURBITS			
1. FRUITFLY: *Bactrocera cucurbitae* Coquillet, *B. dorsalis* Hendel, Tephritidae: Diptera	**Adult:** Reddish brown fly with brown markings on wings. **Maggot:** Apodous, acephalous, dirty white, thicker at one end and tapering at the anterior end.	Maggots attack the fruits at immature stage and feed on the soft pulp of the fruits. It results in premature fruit drop. A resinous globule appears on the fruit at the place of oviposition.	
2. PUMPKIN BEETLE: *Raphidopalpa foveicollis* Lucas, *Aulacophora cincta* Fabricius, *A. intermedia* Jacob, Galerucidae: Coleoptera	**Adult:** *R. fovecollis* adults with reddish brown elytra. *A. cincta* adults have grey elytra with black border. *A. intermedia* adults have blue black elytra. **Caterpillar:** Creamy white with dark oval shield at back.	Adult beetles bite holes on the cotyledon leaves and flowers. Grubs damage the plants by boring into the roots and underground stems and sometimes fruits touching the soil.	
3. SNAKE GOURD SEMILOOPER: *Anadevidia peponis* Fabricius, Noctuidae: Lepidoptera	**Adult:** Dark brown with shiny brown fore-wings. **Caterpillar:** Greenish with white longitudinal line and black tubercles with thin hair arising on them. Last abdominal segment is humped.	Caterpillars defoliate the plants.	
4. SERPENTINE LEAF MINER: *Liriomyza trifoli* (Burgess), Agromyzidae: Diptera	**Adult:** Small black flies. **Maggot:** Leg less, orange yellow.	The maggot soon after emergence mines into the leaf and feed on the mesophyll tissues, resulting in characteristic serpentine white line ending in the shape of snake hood. Infested leaves sun scorch and drop. 50-90% leaves damaged in severe cases.	

1	2	3	4
5. **PUPMKIN CATERPILLAR:** *Palpita (Diaphania) indica* Saund, Pyralidae: Lepidoptera	**Adult:** Medium sized moth conspicuous with transparent white wings with dark broad marginal patches. **Caterpillar:** Elongate bright green caterpillar with a pair of longitudinal sub- dorsal white streaks.	Caterpillar feeds on leaves.	
AMARANTHUS			
1. **AMARANTHUS CATERPILLAR:** *Hymenia recurvalis* Fab. Pyralidae: Lepidoptera	**Adult:** Small to medium sized moth, wings are dark with white wavy markings. **Caterpillar:** Green and slender.	The caterpillars fold the leaves, top shoots and defoliate.	
CHILLI			
1. **CHILLI THRIPS:** *Scirtothrips dorsalis* Hood, Thripidae: Thysanoptera	**Adult:** A minute, delicate light yellow insect. Wings fringed with hairs. **Nymph:** Very minute and wingless.	Both nymphs and adults lacerate the leaf tissue and suck the oozing sap. Infested leaves start curling upwards, crumbling and drop down. Sometimes, even flowers and buds are infested. In severe infestation, the plant withers and finally dries up.	
2. **CHILLI MITES:** *Polyphagotarsonemus latus* Bank, *Tarsonemus transulcens* L. Tarsonemidae: Acarina	Mites are tiny, white, and transparent and found mostly under the lower side of leaves.	Both nymphs and adults suck sap particularly form terminal/axillary tender shoots a devitalize the plant. Infested leaves curl downwards along the margins. Petioles of older leaves are elongated.	

		Younger leaves get reduced in size and form a cluster at the tip of the branch. Affected leaves turn dark green and become brittle.	
3. CHILLI APHID: *Aphis gossypii* G. *Myzus persicae* S., Aphididae: Hemiptera	*A. gossypii*: Brownish green in colour. *M. persicae*: White/ light yellow in colour.	Both nymphs and adults suck sap b y remaining on lower surface of leaves and reduce vitality of the plant. In case of severe attack, leaves curl down, fade gradually and finally dry up. Black sooty mould develops on honey dew excreted by the aphids, which falls on leaves.	
4. CHILLI POD BORER: *Spodoptera litura* Fab., *Helicoverpa armigera* Hub., *Utethesia lotrix* Lin., *S. exigua,* Noctuidae: Lepidoptera		*S. litura, H. armigera* feed on the pericarp and also seeds of fruits. *U. lotrix* feeds on pericarp onl y.	

Q. Draw two important pests of Brinjal, Bhendi, Crucifers, Cucurbits, Amaranthus and Chilli with their symptoms of damage

Ex. No: 3 Date:

Identification of Insect Pests of Coconut, Turmeric, Betelvine, Onion, Ginger and Tobacco and Their Damage Symptoms

Table 3.1Marks of identification, nature and symptoms of damage caused by insect pests of Coconut, Turmeric, Betelvine, Onion, Ginger and Tobacco

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
COCONUT			
1. COCONUTBLACK HEADED CATERPILLAR: *Opisina arenosella* Meyr., Cryptophasidae: Lepidoptera	**Adult:** Medium in sized with pale greyish wings. Few black spots present on forewings. **Caterpillar:** Greenish brown with dark brown head and prothorax and a reddish mesothorax. It posses five reddish brown wavy lines; one on the dorsal side and two on each of lateral sides.	Caterpillar constructs a silken gall on the lower side of leaflet and feeds by scraping the green matter within the gallery. In severe cases orchard gives a burnt appearance even from a distance. Later, bits of the leaf are added to the silken gallery and the length of gallery increases with the increase in the feeding activity.	
2. RHINOCEROUS BEETLE: *Oryctes rhinoceros* Linnaeus, Scarabaeidae: Coleoptera	**Adult:** Stout, black or reddish black beetle with a long horn projecting dorsally from the head. **Grub:** Creamy white and ‘C’ shaped.	Adult beetle feeds on the un opened central whorl of leaves in the crown of the plant. When the affected whorl opens up leaves show characteristic ‘v’ shaped clippings or holes in the leaflets. Frequent infestation results in stunted growth of trees and death of growing point in young plantations. This damage paves way for further fungal and bacterial infection.	

3. **RED PALM WEEVIL:** *Rhynchophorous ferrugineus* Fab., Curculionidae: Coleoptera	**Adult:** Reddish brown weevil with six dark spots on thorax. Head is prolonged into a long snout. **Grub:** Light yellowish with a reddish brown head and is apodous.	Newly hatched grubs bore into the trunk and crown and feed on the internal tissues and make tunnels. In the early stage of infestation, few small holes can be seen in the crown/ soft trunk from which pieces of chewed fibre protrude and brownish viscous liquid oozes. In many cases, the drying up of the young leaves or splitting of the petioles near the area of attack can be observed, the central shoot shows signs of wilting and the crown topples. Large mass of grubs, pupae and adults can be seen inside the trunk near the affected portion. Note the pupa is found within the fibrous cocoon.	

1	2	3	4
TURMERIC			
1. **TURMERIC RHIZOME FLY:** *Mimegralla coerulifrons* Mac., Micropezidae: Diptera	**Adult:** Dipterous fly. **Maggot:** Apodous, taper anteriorly.	Maggots mine into the mid-rib of leaves and enter into the rhizome through the petiole. It results in the rotting of rhizomes and dead hearts.	
BETEL VINE			
1. **BETELVINE BUG:** *Disphinctus politus* W., Miridae: Hemiptera	The bug is slender, active, reddish brown with dark head and antennae, measures about half an inch.	Both nymphs and adults suck sap from tender leaves which develop black spots near the punctures.	
ONION			
1. **ONIONTHRIPS:** *Thrips tabaci* Linn., Thripidae: Thysanoptera	**Adult**: A minute, delicate light yellow insect. Wings fringed with hairs. **Nymph:** Very minute and wingless.	Both nymphs and adults remain at leaf bases and whorls of onion and suck sap. The Infestation causes pale white blotches on leaves. In severe infestation, the leaves dry from top to bottom.	

1	2	3	4
TOBACCO			
1. TOBACCO CATERPILLAR: *Spodoptera litura* Fabricius, Noctuidae: Lepidoptera	**Adult:** Medium sized moth with stout body. Forewings pale grey to dark brown in colour withwavy white markings and hind wings white with smoky margins. **Caterpillar:** Velvety black with yellowish green dorsal stripes and lateral white bands. A dark ring like marking is seen on anterior and posterior region in early stages.	During early instar, caterpillars scrape chlorophyll content of leaf lamina giving it a papery white appearance. During later instars, skeletonizes the leaves leaving only veins and petioles.	
2. WHITEFLY: *Bemisia tabaci* (Gennadius), Aleyrodidae: Hemiptera	**Adult:** Minute insect with yellowish body and whitish wings. **Nymph:** Oval scale like and yellowish in colour.	Both nymphs and adults suck sap from lower side of leaves. It results in reduction of plant vigour which ultimately leads to shedding of flowers. Sooty mould develops on infested leaves due to excretion of hone y dew and it hampers the photosynthetic activity.	

1	2	3	4
3. TOBACCO APHID: *Myzus persicae* S., Aphididae: Hemiptera	**Adult & Nymph:** Greenish/light pink, winged female has a black head and greenish abdomen with one/ two transverse dark bands and four lateral dark spots.	Both nymphs and adults suck sap by remaining on lower surface of leaves and reduce vitality of the plant. In case of severe attack, leaves curl down, fade gradually and finally dry up. Black sooty mould develops on honey dew excreted by the aphids, which falls on leaves. They transmit tobacco ring spot virus and rosettes disease.	
4. TOBACCO STEM BORER: *Scrobipalpa heliopa* L., Gelechidae: Lepidoptera	**Adult:** Dark brown moth. **Caterpillar:** Slender, dark headed and pinkish.	Caterpillar mines into the leaf axil and then into stem. Bored stems become hollow, swollen and forms a gall.	

Q. Draw two important pest of Coconut with their symptoms of damage

Q. Draw one important pest each of Turmeric, Betelvine, Onion and Ginger with symptoms of damage

Ex. No: 4 **Date:**

Identification of Insect Pests of Mango, Cashew and Banana and Their Damage Symptoms

Table 4.1Marks of identification, nature and symptoms of damage caused by insect pests of Mango, Cashew and Banana

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
MANGO			
1. MANGO LEAFHOPPER: *Amritodus atkinsoni* (Lethierry), *Idioscopus clypealis* (Lethierry), *I. niveosparsus* (Lethierry), Cicadellidae: Hemiptera	*A. atkinsoni*: largest light brown with two spots on scutellum. *I. clypealis*: smallest, light brown with spots on scutellum and a dark spot on vertex. *I. niveosparsus*: medium sized, with three spots on scutellum and prominent white band across its light brown wings.	Both nymphs and adults suck sap from leaves, tender shoots and inflorescence. Flower buds, flower *etc.*, first become flaccid then wither and die, leading to reduction in fruit set. They produce sticky honey dew which encourages the development of sooty mould and which in turn hinders the photosynthetic activity.	
2. MANGO TREE BORER: *Batocera rufomaculata* Degger, Cerambycidae: Coleoptera	**Adult**: Brownish grey with two pink spot and a pair of lateral spines on thorax. **Grub**: White, fleshy with dark brown head and strong jaws.	Grubs tunnel through the stem, eating away the nutrition-translocation system and ultimately kill the tree. Depending on the intensity of attack, the affectedtrees show the symptoms like withering of leaves and twigs and drying of entire tree. A white/yellowish exudates dripping down of the stem indicate the occurrence of stem borer, during its early stage of attack.	

1	2	3	4
3. MANGO STONE WEEVIL: *Sternochetus mangiferae* Fabricius, Curculionidae: Coleoptera	**Adult**: A stout, greyish brown weevil. **Grub:** White, thick, fleshy and legless.	Grub soon after hatching, burrows into the mesocarp flesh of tender fruit and reaches the region where the endocarp seed coat is still very soft. Once, the grub crosses this barrier of seed coat, it reaches seed endosperm to complete its life cycle. In the mean time, the fruit develops and heals up the larval tunnel, so that no external symptom is visible. Adult, who emerges from seeds, also feeds on seed. This hastens the maturity of infested fruit.	
4. MANGO LEAF WEBBER: *Orthaga exvinacea* Wlk., Noctuidae: Lepidoptera	**Adult:** Medium sized, dark brown stout moth. **Caterpillar:** Slender pale green, 35 mm long	Caterpillar webs terminal leaves and feed by scraping inside. Leaves are skeletonised. Flower stalks do not emerge properly.	
CASHEW			
1. CASHEW TREE BORER: *Placaederus ferrugineus* Linneaus, Cerabycidae: Coleoptera	**Adult:** Medium sized, dark brown longicorn beetle. **Grub:** Creamy white, robust and fleshy.	Newly hatched grubs feed on the sub-epidermal and soft wood tissues below the bark. Gradually, they bore into the stem and root Bore holes are plugged with chewed fibre an excreta. Gummy, resinous material oozes form the attacked portion. In the later stages, grubs feed on the inner tissue by forming irregular tunnels. When vascular tissues got damaged, leaves turn yellow and twig and branches dry leading to the death of tree.	

1	2	3	4
2. CASHEW SHOOT AND BLOSSOM WEBBER: *Lamida moncusalis* Walker, Pyralidae: Lepidoptera	**Adult:** Medium sized dark brown moth. **Caterpillar:** Newly hatched pale white caterpillar turns to reddish brown, when full grown and bears lateral longitudinal bands and pinkish dorsal lines.	Caterpillar webs the leaves and feeds. It webs the inflorescence also, at the time of blossoming. Apples and nuts are also damaged. They feed by scraping the upper green layer of apples and nuts when they are tender. It results in cracking of tissues and retardation in nut development.	
3. CASHEW LEAF MINER: *Acrocercops syngramma* M., Gracillaridae: Lepidoptera	**Adult:** Minute moth silvery grey in colour. **Caterpillar:** Yellowish and turns reddish brown.	Caterpillars mine into leaves and roll the fresh leaves. The thin epidermal layers of tender leaf swell up in the mined areas and appear as whitish blistered patches. In older leaves, big holes are formed due to drying and crumbling of mined areas.	
BANANA			
1. BANANA RHIZOME WEEVIL: *Cosmopolites sordidus,* Curculionidae: Coleoptera	**Adult:** Medium, dark brown, ridged, drawn out mouthparts. ½" long elytra do not cover the abdomen completely. **Caterpillar:** Dwarf, stout with red head and powerful mandibles.	Grubs tunnel through pseudostem and rhizome making circular hole, which increase in size with the growth of grubs. Tunnels up to 2-3' in stem with 6-10 grubs/stem. Plants break down at tunnelled portion. Less number of fruits and suckers. Circular holes with black rotten tissue of rhizome, plugged with excreta.	

Q. Draw two important pests of mango, cashew and banana with their symptoms of damage

Ex. No: 5 Date:

Identification of Insect Pests of Citrus and Sapota and Their Damage Symptoms

Table 5.1Marks of identification, nature and symptoms of damage caused by insect pests of Citrus and Sapota

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
CITRUS			
1. CITURS BUTTERFLY: *Papilio demoleus* Linnaeus, Papilionidae: Lepidoptera	**Adult:** Big, beautiful butterfly with yellow and black markings on fore wings. Hind wings have a brick red oval patch near the anal margin and tail like extension behind. **Caterpillar:** Dark brown with irregular white markings on their body, when young, changes to deep green colour, when fully grown.	Caterpillars feed voraciously on leaves, leaving behind midribs only. In general, they start feeding from the margin inwards, reaching the midrib.	
2.CITRUS FRUIT SUCKING MOTH: *Eudocima maternal* Linnaeus, *E. fullonica* Linnaeus, *E. ancilla* Linnaeus, Noctuidae: Lepidoptera	**Adult:** *E. maternal:* Brown forewings with a white stripe and hind wings with a circular black spot in the middle. *E. fullonica*: Brown black fore-wings and yellowish hind wings with kidney shaped black spot. *E. ancilla*: Cylindrical, stout, semilooper with dark brown velvety colour. **Caterpillar:** Cylindrical, stout, semilooper with dark brown velvety colour.	Adult moths pierce their proboscis into the fruits and suck the juice. This results not only in fruit drop, but also exposes the fruits to bacterial/ fungal infection due to which fruits rot/ severely suffer in quality.	

1	2	3	4
3. **CITRUS LEAF MINER:** *Phyllocnistisciterlla* Staint, Gracillaridae: Lepidoptera	**Adult:** Silvery white with brown striped forewings having a prominent black spot near the tip. Both pairs of wings fringed with hairs. **Caterpillar:** Yellowish green slender with brownish mandibles.	Caterpillar mines in between the epidermal layers of the leaf in a zig-zag manner. As a result, the leaf gets deformed, irregularly curled up in shape, unhealthy in look,defective in its function and finally it dries and falls off. Sometimes, larvae mine the outer layer of the skin of young green twigs.	
4.**RUSTMITE:** *Phyllcoptruta oleivora* Ahmead, Eriophyidae: Acarina	**Adult:** Minute, yellowish, wedge shaped, worm like. **Larva:** Minute light yellow, resembles adult except in size.	The mite punctures the epidermal cells of leaves and tender fruits. After about a month leaves and fruits develop dusty appearance ultimately turning pink/ black/ rusty spots. At this stage the affected fruits are conspicuous and growers call it as "**Mangu**" in Andhra Pradesh.	
5. **BARKBORER:** *Indarbela tetraonis* Moore, Metarbelidae: Lepidoptera	**Adult:** Medium sized well built pale brown moth with wavy grey markings on the wings. **Caterpillar:** Dirty pale brown with dark head and measures about an inch an half in length.	The caterpillars make zig-zag tunnel on the stem, branches and feed on the tissues preferably at fork region. They make galleries with silken web made up of fine chips of wood and excretory pellets. Caterpillars move in the galleries at night and spread to other parts. Such galleries/ribbons are seen hanging particularly at branches. Attack is more on older trees in neglected orchards.	

1	2	3	4
SAPOTA			
1. SAPOTA LEAF WEBBER: *Nephopteryx eugraphella* Rag., Pyralidae: Lepidoptera	**Adult:** Small grey moths. **Caterpillar:** Pinkish brown with closely set longitudinal lines on dorsum.	The caterpillar webs the leaves and also feeds on flower buds and fruits.	

Q. Draw one important pest each of Citrus and Sapota with symptoms of damage

Ex. No: 6 **Date:**

Identification of Insect Pests of Grapevine, Pomegranate and Guava and Their Damage Symptoms

Table 6.1Marks of identification, nature and symptoms of damage caused by insect pests of Grapevine, Pomegranate and Guava

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
GRAPEVINE			
1. GRAPEVINE FLEA BEETLE: *Scelodonta strigicolis,* Chrysomelidae: Coleoptera	**Adult:** Small, coppery brown with three prominent circular patches on each elytra-8mm long. **Grub:** Dirty white 8 mm long, found in soil.	Adults are destructive to the new flush after pruning. Adults feed on sprouting buds. Adults also feed on mature leaves. Grubs feed oncortical layers of roots (not causing much loss). Completely feed sprouting buds. Rectangular shot holes on leaves.	
2. GRAPEVINE THRIPS: *Rhipiphorothrips cruentatus,* Thripidae: Thysanoptera	**Adult:** One mm long with fringed wings. **Nymph:** Reddish brown, carrying a black drop of shiny excretory droplet.	Nymphs and adults lacerate tissues of tender foliage, flower stalk, tender fruits. Pale patches to shining spots/ dots on leaves and scab on berries.	
3. GRAPEVINE MEALY BUG: *Maconellicoccus hirsutus,* Pseudococcidae: Hemiptera	**Female:** Light pinkish with functional mouth parts, wingless, sessile. **Male:** With one pair of wings and degenerate mouth parts.	Crawler move to succulent parts like leaves, buds, and petioles, bunches and settle and become sedentary and cause desapping. Malformation of shoots and leaves. Sooty mould on honey dew and movement of black ants can be seen.	

1	2	3	4
GUAVA			
1. GUAVA MEALY BUG: *Ferrisia virgata,* Pseudococcidae: Hemiptera.	**Female:** Big, apterous with long prominent filaments at posterior end covered with waxy filaments.	Pest infests pedicels, stalks under surface of leaves, shoots and fruits. Sooty mould develops on infested parts. Twisting and malformed twigs, leaves and fruit drop.	
2. TEA MOSQUITO BUG: *Helopeltis antonii,* Miridae: Hempitera.	**Adult:** Reddish with 'T' shaped raised/ knobbed process present mid-dorsally on the thorax.	Nymphs and adults tap fruit surface causing scab on fruit surface. On twigs black linear scars. On leaves, reddish streaks.	
POMOGRANATE			
1. POMOGRANATE BUTTERFLY: *Deudorix isocrates* (Fab.), Lycaenidae: Lepidoptera.	**Adult:** Medium sized butterfly with tail like extension at the lower margins of hind wings. **Caterpillar:** Full grown caterpillar dirty brown, short and stout built covered with a few short hairs and measures about ¾" in length.	The caterpillar bores into the fruit. No entry hole can be made out. The fruit appear healthy, but the caterpillar inside eat the seeds. Severely infested fruits show holes often plugged by the anal segment of the caterpillar or its excreta.	

Q. Draw one important pest each of grapevine, pomegranate and guava with symptoms of damage

Ex. No: 7 **Date:**

Identification of Insect Pests of Flower and Ornamental Plants and Their Damage Symptoms

Table 7.1Marks of identification, nature and symptoms of damage caused by insect pests of Flowers and Ornamental plants

INSECT PARTICULARS 1	MARKS OF IDENTIFICATION 2	NATURE AND SYMPTOMS OF DAMAGE 3	OBSERVATION/ FIELD DIAGNOSIS 4
PESTS OF ROSE			
1. **THRIPS** *Rhipiphorothrips cruentatus* Thripidae: Thysanoptera	**Adult** Dark brown, black in colour **Nymph:** Reddish in colour	Infest grain both in store and field. Both grubs and adults damage the grain by feeding inside the kernels. Adults cut a circular hole on the grain.	
2. **SCALE** *Lindingaspis rossi*, *Aonidiella aurantii* Diaspididae: Hemiptera	Red scales completely cover the stem.	Both nymphs and adults suck sap causing drying and death of plants.	
3. **ROSELEAF** **CATERPILLARS** *Euproctis fraterna*, *Porthesia scintillans*: Lymantriidae *Latoia lepida*: Limacodidae *Achaea janata*: Noctuidae Lepidoptera .	**Adult** **1.** Yellow moth with pale transverse lines on the forewings **2.** Yellow moth with spots on the edges of wings **3.** Green moth with brown markings at the base of the wings **4.** Grayish moth with wavy lines on fore wings and white patches on hind wing **Caterpillar:** **1.** Reddish brown with red head surrounded by white hairs and long tufts of hairs all over the body and a long pre anal tuft.	Caterpillars defoliate the leaves	

	2. Yellow coloured with brown head, yellow stripe with a central red line on the body **3.** Slug like flat ventrally greenish body ,scoli tipped red or black		
4. ROSE CHAFER BEETLE *Oxycetonia versicolor* Cetoniidae: Coleoptera .	**Adult:** Beetles are red coloured with black markings.	Adults feed on leaves, flowers during night causing irregular feeding mark on buds and flowers.	
PESTS OF JASMINE			
1. JASMINE STINK BUG *Antestiopsis cruciata* Pentatomidae: Hemiptera	**Adult:** Dark brown shield shaped bug with orange and white markings o wings **Nymph:** Dark brownish black and round	Nymphs and adults suck sap from flowers, tender plant portions causing heavy damage to flowers and yellowing and drying of leaves. Sometimes, they feed in large numbers on tender shoots and buds preventing flower formation	
2. JASMINE BUD WORM *Hendecasis duplifascialis* Pyralidae: Lepidoptera	**Adult:** Small white moth with black palp and three lines on the abdomen an the hind legs **Caterpillar:** Dark green with black head	Greenish caterpillar attacks two or three buds and buds are webbed together by silken threads. Petals are eaten away by larva resulting in buds with bore holes, webbings soiled with excreta. Pupation is in soil.	
3. JASMINE GALL/ FELT MITE *Aceria jasmini* Eriophyidae: Acarina.		It produces white felt like hairy outgrowth on the leaf surface, tender stems and buds leading to stunted growth and suppression of flower development	

PESTS OF CHRYSANTHEMUM			
1	**2**	**3**	**4**
1.CHRYSANTHEMUM BLACK APHIDS *Macrosiphoniella sanborni* Aphididae: Hemiptera	**Adult:** Slender, dark brown flat beetle with a row of six teeth like structures on either side of thorax. **Grub:** Slender pale cream with two dark patches on each segment.	Nymphs and adults infest tender shoots sucking sap and causing yellowing and drying of tender shoots, devitalisation and stunted growth.	

Q. Draw one important pest each of Rose, Jasmine and Chrysanthemum with symptoms of damage

Ex. No: 8 **Date:**

Study of Different Species of Honey Bees and Bee Hives

Apiculture: The science and art of rearing honey bees.
Apiary: A bee yard where colonies, hives and other equipment are assembled in one location for bee keeping.

'Apis' means bee. The scientific names of different species of honeybees begin with the generic name *Apis*. Apiculture or bee-keeping is the art of caring for, and manipulating colonies of honeybee in large quantity, over and above their own requirement.

Importance of bee keeping/apiculture:
1. Bee keeping does not require a)
Own land
b) Labour
c) Full time attention
d) Heavy continuous investment, except initial establishment cost.
2. Does not compete with other agricultural operations/activities.
3. Provides additional income through a) Honey-a hygienic food, tonic and medicine,
b) Bee products – wax, propolis, royal jelly, pollen and bee venom, c) Sale of colonies.
4. Provides employment to village artisans for fabricating equipment.
5. Provides wealth and valuable food from material (i.e., pollen and nectar) at presentgoing waste.
6. Improves crop yields and
7. Helps to maintain natural plant diversity through cross pollination.

Limitations:
Lack of
a) Awareness about importance of bee keeping
b) Knowledge about bee management c)
Skill in bee management
d) Patience to gain experience in bee keeping e)
Man power to popularize bee keeping
f) Expectation of immediate returns g)
Fear of bee stings
h) Non availability of equipment and bees at door steps i)
Increased cost of timber
j) Psychology of bee keepers to discourage the others to enter the profession.

Species of honey bee:
Honey bees:
- Well known, popular and economically beneficial insects
- Social insects like ants, termites and some wasps
- Vegetarians unlike ants and wasps
- Derive protein from pollen, carbohydrate from honey which they make from nectar
- Live together in colonies, cooperate in foraging tasks and take care of young ones

The position of honey bees in the animal kingdom is mentioned below:

Phylum: Arthropoda
Class : Hexapoda/Insecta
Order : Hymenoptera
Family : Apidae
Genus : Apis
Species:

a) *A. dorsata*
b) *A. florea*
c) *A. indica*
d) *A. mellifera*

Table 8.1 Important Honey bee species

Sl. No.	Character	Rock bee/ giant bee *A.dorsalis*	Little bee/ dwarf bee *A. florea*	Indian bee *A. cernana indica*	European/ Italian bee *A. mellifera*
1.	Wild/ domesticated	Wild in nature	Wild in nature	Domesticate d species	Domesticated species
2.	Size	Largestof all species	Smallest of all the species	Intermediate	Bigger than *A.cerana* but smaller than *A.dorsata*
3.	Distribution	Present all over India in plains an inhilly areas upto 1600 m above sea level	Found in plains of India upto 300 m above sea level	Present all over India in plains and hilly areas upto2500m above sea level	Imported species. Got acclimatized to different climatic conditions all over India
4.	Worker	Light brown 16-18 mm in size	Deep black with white strips on the posterior part of the bright orange abdomen	Thorax dark coloured with brown hair. Abdomen brown with dark bands	Blackwith yellowish hairs.
5.	Queen	Darker and much larger than workers and drones	Bigger and abdomen is golden brown	Thorax dark and sparsely hairy. Abdomen and legs coppery brown. Abdomen is big, distended and without black bands.	Brownish body longer than worker and drone
6.	Drones	Black and as big as workers	Black with smoky brown hair on the abdomen	Stout and slightly bigger than workers	Amber/ yellow body with yellowish hair
7.	Temperament	Ferocious	Very mild, but they do sting when irritated	Gentle	Moderately mild
8.	Nesting/comb construction	Constructs single, big comb in open where they get some diffused light (1-2 m from side to side and 0.5 to 1.25 m from top to bottom	Constructs single, small comb (15 cm long and 30 cm height) in open where they get some diffused light	Constructs several parallel combs (13-18) i.e., parallel to the direction of the entrance in plains and at right angles to the entrance at high altitude	Constructs a series of parallel combs inside some enclosures.

9.	Place of nesting	Suspends its comb to large tree branches/ building projections/water reservoirs/ceilings etc protecting it from direct sun rays and rain	Constructs the comb in the files of cotton sticks/bushes/ house chimneys/ house arches and other such places	In nature constructs combs inside some enclosures such as hollows in the walls/rocks/tree trunks/ inverted baskets etc.	In nature, construct comb in the hollows of walls/rocks/tree trunks/inverted baskets etc
10.	Honey gathering per year/colony	Heavy gathers 37 kg	Poor gathers 0.5 to 1.0 kg	Fair gather 3-5 kg in plains, but yields are as high as 20-25 kg in Kashmir	15-20 kg. A strong colony can gather upto 50 kg if abundant bee flora is available

Morphology of honey bee:

Honey bees share the general characters of class Insecta. But the organ systems are variously modified to lead a specific life i.e., food habits, social life etc.

Body:

- Covered with a hard external skeleton to protect the internal organs.
- Divided into three regions i.e., head, thorax and abdomen.

Head:

Bears
a) A pair of geniculate antennae. Flagellum (third segment) having chemo and mechanoreceptors.
b) A pair of large compound eyes on lateral sides and three simple eyes (Ocelli). Bee can distinguish colour, but are red blind.
Ocelli: Perceive only the degree of light and do not form an image on the retina.
c) A pair of mandibles: Mandibles differ in the three castes.
d) Mouth parts: These are modified for sucking and lapping in worker. The proboscis (tongue) is formed by median labium and two lateral maxillae and is used for ingesting liquids.
e) Thorax: Consists of three segments and joined to the abdomen by a narrow propodeum. Besides locomotion, legs modified to perform other function i.e., prothoracic legs for antenna cleaning, meta thoracic legs for pollen and propolis collection, meso-thoracic legs for wax picking.
f) Abdomen: bears a sting, wax and scent glands and genital organs and viscera internally.
g) Sting: In worker, the ovipositor (egg laying apparatus) is modified into a sting
h) Wax glands: Situated in the sternites of 4th to 7th abdominal segments. Become active in worker bees at the age of 14-18 days. Wax is secreted in liquid form which solidified into thin flakes
i) Scent glands: Present in the thin membrane connecting the last two abdominal terga. Bee bends her abdomen and exposes the membrane to produce the scent. The odour produced from the cells is derived from scented waste products of metabolism.

Biology:

Honey bees undergo metamorphosis. Through four developmental stages i.e., egg, larva, pupa and adult.

Eggs:

Queen lays both fertilized and unfertilized eggs which are similar in size and shape. Fertilized eggs develop into females (worker and queen) and unfertilized eggs develop into drone bees. Eggs are laid singly and attached vertically to the bottom of cell wall. Eggs hatch on 3^{rd} day.

Larv:

After hatching, all the larvae fed with royal jelly (bee milk produced by worker bees) for 3 days. Thereafter, the worker and drone larvae are fed with nectar and pollen. A queen larva is fed continuously with royal jelly up to 8^{th} day, when the queen cells are further packed with royal jelly and are sealed. The capped royal larva (queen) continues to feed until it pupates. Initially, the larvae are loop shaped, but towards cell capping, they get stretched in the cell with head facing upwards. After passing through four moults, larvae enter into the prepupal and final pupal stage.

Pupa:

Before entering into pupal stage, the larva spins a thin silken cocoon around itself and undergoes gradual, but drastic changes. At this stage, head, thorax and abdomen are clearly distinguishable. The compound eyes and various appendages are also clearly visible.

Adult:

When pupal development is completed, the insect metamorphoses into adult and finally adult bee emerges by gnawing its way out of the sealed cell. The development stages of all the three castes of honey bees are similar, but the time taken for development, sexual maturity and also longevity of different castes are variable as shown in table.

Bee Hives:

A beehive is an enclosed structure in which some honey bee sps live & raise their young. Primitive Beekeeping was revolutionized through discovery of Bee space by Rev. L.L. Langstroth and successful use of movable frames which in turn led to designing of modern beehive.

• The "Modern" bee hive is based on understanding of "Bee Space" 1/4"- 3/8".

• Bee space (passage way) is the space required between any two frames for bees to move about between the combs & too small to build combs & too large to deposit propolis.

• Bee space for *Apis mellifera* is 5/16 "& for *Apis cerana* is 1/ 4"

Different types of bee hives:

1. Pot hive
2. Hook hive
3. Madusagar hive
4. House hive
5. Nucleus hive Jeolikote's hive
6. Dadant's hive (Single walled & Double walled)
7. British standard hive
8. Langstroth's hive (*A.mellifera*)
9. Newton's hive (*A.cerana*)

• Natural beehives (referred to as "nests") are naturally occurring structures occupied by honey bee colonies,

• The beehive's internal structure is a densely packed matrix of hexagonal cell made of beeswax, called a honeycomb. Bees use cells to store food (honey and pollen),& to house "brood" (eggs, larvae,& pupae).

- **Natural bees' nests:**

Honey bees in subgenus Apis use caves, rock cavities & hollow trees as natural nesting sites. Members of other subgenera have exposed aerial combs.

Nests - composed of multiple honeycombs, parallel to each other, with a relatively uniform bee space, usually with a single entrance.

- **Artificial bee hives:**

• Traditional beehives

• Modern beehives

• Skeps are made of baskets with single entry points at the bottom for the bees & no structure inside. It is not feasible to inspect bees inside, & harvesting means destroying entire hive by killing / driving away bees.

Bee Gums – Hives of this type are located exactly on hollowed body part of gum trees. Sticks are attached to honey combs for easier pulling out by the time of harvesting.

Langstroth Hive:

• Frames - thin rectangular structures (wood/ plastic) & with a wax / plastic foundation to draw out the comb - hold beeswax honeycomb formed by bees.

• Ten frames side-to-side/hive & leave right amount of bee space between each frame & between end frames & hive.

• Frames - reinforced with wire, making it possible to extract honey in centrifuges to spin honey out of comb.

• Empty frames & comb - returned to hive for use in next season.

• Bees require - require 1 kg of beeswax to make 8 kg of honey
Comb reuse - significantly increase honey production.

National hive:

• Widely used hive in the UK. A square hive, with grooves to serve as hand grips.

• Frames - smaller than standard Langstroth hive& have longer hand grips (or "lugs").

WBC hive:

• Invented by & named after William Broughton Carr

• A double-walled hive with an external housing that splays out towards the bottom of each frame covering a standard box shape hive inside.

• Offers extra level of insulation for bees by its double-walled design.

• Inconvenient to remove external layer before hive can be examined

QUESTIONS

1. What does “Apis”, a latin word mean literally?

2. Write three advantages of bee-keeping.

3. Name the two species of honeybee that can be domesticated.

4. Name the three castes in a honey bee colony

Ex. No: 9 **Date:**

Study of Equipment for Handling Honeybees

The successful use of movable frames and the discovery of bee space revolutionized the primitive way of keeping bees and paved the way for designing of modern bee hive. In1851, Rev. L. L. Langstroth improved the earlier type of hive based on his discovery of "Bee Space". Bee space (Passage way) is the space required between any two frames for the bees to move about between the combs and is too small to build combs and too large to deposit propolis. Bee space for *Apies mellifera* is 5/16 inches and *Apis cerana indica* is ¼ inches. Langstroth hive and Newton's hive are generally used for beekeeping with *A. mellifera* and *A. cerana indica* respectively.

Beehive:

- It is a tool/equipment used in a scientific method of bee keeping.
- It consists of a bottom board, brood chamber, brood frame, super chamber, super frame, inner cover and top cover.

Table 9.1 Bee Keeping Equipment

Beehive stand	This is made of RCC or wood or iron with provision for water cups to prevent ants from entering beehive. Bee hive is kept on the beehive stand.
Smoker	This is made of a tin or copper container attached with a leather bellow. This is used to smoke bees to subdue them while handling.
Hive tool	It is made of a thick iron plate to clean the hive, to handle the frames and to remove propolis etc.
Bee veil	This is made of mosquito net type material for being worn to protect the face from being stung by bees while handling.
Gloves	These are used to protect hands from bee sting while handling.
Honey extractor	This is made out of tinned copper, brass or zinc drum with basket cages to hold frames and wheel to rotate them in order to extract honey by centrifugal force generated in it.
Queen gate	This is made out of zinc sheet with perforations to prevent queen from
Queen excluder	This is made out of zinc sheet with perforations and is placed between broad chamber and super chamber to prevent the movement of queen bee
Drone excluder	This is used to prevent the re-entry of drones into the hive after the bees
Drone trap	It is useful for fixing in front of the hive entrance when workers and drones come out for play flight. Workers can easily go out through the groove at the bottom, but drones are trapped. Drones, thus trapped can be removed and killed, when they are no longer required in the hive.

Comb foundation sheet	This is made of pure wax. It is used to aid the bees to construct straight parallel combs.
Dummy division board	This is useful to reduce the inner area of the broad chamber so that the bees can be confined to a limited space when bee population in the hive is low.
Swarm trap	It is a rectangular box open at one of the broader sides and wire gauge fixed to about 2/3 of its height on the other side and the remaining 1/3 portion with a queen excluder sheet made of zinc in a slanting position. During swarming season, when bees construct queen cells, the box is kept on the alighting board with open side
Bee brush	It is used to brush off bees from honey comb before it is taken away for extraction.
Feeders	These are used to feed sugar syrup to bees. The division board feeder is commonly used. It is a wooden trough of regular frame dimensions of the hive to hang in the hive just like any other frame with a wooden strip to serve as a float
Queen cages	Several types of queen cages are available for caging the queens
Queen cell protector	A queen cell which may have to be introduced from a queen-right to a queen less colony is protected with a queen cell protector until its acceptance by the bees

Bee pasturage:

Honey bees have close link with flora because they live solely on nectar and pollen. To maximize the honey production, bee keeper should have a thorough knowledge of floral cycle, on set of major honey flow and dearth periods.

1. **The plants which are visited by bees only for nectar are:**
   Tamarind (*Tamarindus indicus*) (rich source), Neem (*Azadirachta indica*), Soap nut (*Sapindum* spp.), *Eucalyptus* spp., Pungam (*Pongamia glabra*), *Morinda tinctoria, Prosopis spicigera, Quisqualis indica, Legasca mollis, Tribulus terrestris, Glyricidia maculata.*
2. **Plants which supply pollen to the bees are:**
   Sorghum (rich source), maize, roses, bajra, finger millet, pomegranate, sw

   eet potato, tobacco, castor, tea etc.

3. **Plants which supply both nectar and pollen are:**

Banana, citrus, apple, pear, plum, peach, guava, mango, coconut, sesamum, safflower, mustard, cruciferous and cucurbitaceous vegetables, bhendi, onion, Lucern, clover, hollyhock, aster, *Cassia fistula*, cotton (very rich source).

Honey extraction and processing:

When the honey flow begins to slow down, the frames with honey should be removed for extraction. To remove honey comb, the colony is smoked, the desired combs taken out and bees brushed off with a soft brush or leaves. These combs are placed in tight hive bodies, carried to the extraction room. A room with wire gauged bee tight doors is necessary for honey extraction. Frames should be uncapped with a hot knife. The uncapped frames should be placed in extractor and rotated slowly and then at a faster speed. Then the frames are reversed and extraction is again worked. Finally, honey collected in the container is strained and packed in tins or bottles. After the extraction, the place should be swabbed with water and the appliances cleaned. The empty wet combs should be returned to the hives for bees for cleaning and reuse.

QUESTION

1. **Draw any four honey bee rearing equipment**

Ex. No: 10 Date:

Study of Insect Pests and Diseases of Bees

A) Greater wax moth, *Galleria melonella*

Adult is brownish grey, 10-18 mm length. The colour and size of adults vary according to food eaten during larval period. Dark brown combs containing pollen give rise to darker and bigger adults. The fore wing of male has a semi lunar notch, while that of females are smooth. Female lays 300-400 eggs in clusters in 4-10 days. Eggs hatch in 3-5 days. Caterpillars are highly active and consume gnawed pieces of comb. They soon spin silken tunnels in the comb or tubular galleries on bottom board to protect them. Life cycle is completed in 6 weeks to 6 months. Caterpillars eat away the combs by making tunnels in midrib of combs. The presence of small pieces of minute particles of wax outside the holes is the first indication of entry of larva into comb. Later, faint webbings are perceptible over some cells of comb. In case of severe infestation, brood rearing is stopped and the bees desert their nest.

Management:

a) Maintain the colonies strong to resist wax moth.
b) Keep the hives without cracks and crevices.
c) Reduce hive entrance size for effective guarding by bees.
d) Keep the bottom board neat and clean without debris.
e) Hold the comb against sun rays to observe the larvae.
f) Extra combs stored should be fumigated with sulphur.

B) Black ant, *Componotus compressus* Fab.

They carry adult bees as well as broad.

C) Bee hunter wasps, *Palaras orientalis* Kohl, *Philanthus ramakrishnae* T.

They wait near hive entrance and collect 20 bees in a day. Apart from loss of workers, the whole colony is frightened and disturbed.

Diseases:

1. Broad diseases:

Honey bee brood suffers from a variety of diseases. Adult bees are not affected by brood diseases, but they can spread the causal organism. Brood diseases are more serious than adult diseases.

Bacterial diseases:

a) American foul brood (*Bacillus larvae*)
b) European foul broad (*Mellissococus pluton*)

Viral diseases:

a) Thaic sac brood b) Sac brood

Fungal diseases:

a) Chalk brood (*Ascophera apis*)
b) Stone brood (*Asperigillus flavus*)

Table 10.1 Symptoms of brood diseases:

	American foul brood	European foul brood
General appearance of brood comb	Brood irregular, intermingling of capped, open and punctured cells. Much dead brood in capped cells with punctured capping and cells uncapped by bees.	Brood irregular. Dead brood mostly in open cells
Time of death	Late larval/early pupal stage	Coiled larvae in unsealed cell and rarely late larval
Cell capping	Cappings sunken and usually have holes	Some cappings perforated
Consistency of dead Brood	At first watery/Slightly viscid becoming ropy, finally brittle	At first soft and watery, afterwards pasty, rarely visual and ropy
Odour of dead brood	Putrid faint	Strong and sour
Brood affected	Worker, rarely drone or queen	Worker, drone and queen
Control	Tetramycin 0.25-0.40 g in 5 lit sugar syrup fed to infected colonies. Repeat after 7-10 days	Tetramycin 0.25-0.40 g in 5 lit sugar syrup fed to infected colonies. Repeat after 7-10 days.

Thai sac brood disease:

The virus multiples in adults which transmits to larvae. Infected brood die in prepupal, but in unsealed stage. Dead larvae straighten out and lie on their backs, with tip of head capsule turned upwards. Dead larvae or Prepupae dry up in brood cells forming loose scales. Affected larvae are yellow/greyish, later darkening to blackish, the change in colour first starts from mouth parts and head. No definite preventive/curative measures available.

- Keep the colonies strong
- Avoid exchange of hive parts and
- Restrict the bee movement

Sac brood virus:

Infected larvae fail to pupate and lie stretched on their back with head turned upwards. Larvae become sac like due to filling of fluid between new integument and unshed skin. Colour of larvae turns pale yellow and finally become dark brown, the darkening starts from head.

2. Adult bee diseases

a. Protozoan diseases – *Nosema apis*

Infected bees become dysenteric with distended and swollen abdomens. They have disjointed wings and found crawling in front of the hive. Disease is severe during spring and wintering with more colony strength with sufficient brood food stores and open sunny sites helps in overcoming the disease incidence.

b. Acarine disease-

i. ***Acarapsis woodi:*** Endoparasitic mite of adult bees. It infests the trachea of first thoracic spiracle where they suck haemolymph.

Symptoms:

I. Presence of bee crawlers at hive entrance
II. Bees are unable to fly and wings are disjointed in K winged condition
III. Infested bees are short lived

ii. ***Varroa jacobsi:***

Female mite enters the cell of 5 – 5.5 day old larvae before sealing and lays 2-5 eggs on walls of the cell. Feeds on haemolymph of the larva or pupa. Adult female mite lives on adult workers and drones under abdominal sclerites. They feed by making holes in the intersegmental membrane. Dead mites can be seen on bottom board in the debris. In queen rearing and mating yards, *Varroa* infestation causes shortage of drones for mating.

iii. ***Tropilaelaps clareae***

It is an ectoparasitic mite. Infested colonies have irregular brood pattern, dead and malformed larvae and pupae in brood combs. Malformed adults with missing or poorly formed wings and shrunken abdomen can be observed crawling around the hive.

It can be controlled by dusting with sulphur @ 1 g/comb.

Ex. No: 11 **Date:**

Study of Different Species of Silkworm

Sericulture or silk production

It is the breeding and management of silk worms for the commercial production of silk. Sericulture is an important industry in Japan, China, India, Italy, France and Spain.

Table 11.1 Different species of silkworm

Sl. No.	Common Name	Scientific Name	Host
1.	Mulberry silkworm	*Bombyx mori*	Mulberry
2.	Eri silkworm	*Philosamia ricini*	Castor
3.	Muga silkworm	*Antheraea assama*	Som, Soalo
4.	Tasar sillworm	*Antheraea mylitta*	Arjun, Sal

Source of silk – The silkworm

The silkworm is the larva or the caterpillar of the moth *Bombyx mori* (popularly called the silk moth) the total life history of the moth from egg to adult take 50 days. The different stages are as follows:

a. Egg : 10 days
b. Larva (4 stages) : 30 days
c. Pupa (Cocoon) : 10 days

(i) Adult

The adult silk moth is a creamy white moth that has a flat body and a wing expanse of about 5 cms. It takes no food and seldom attempts to fly. It lives for only 2 to 3 days. After mating, the female moth lays 300-500 eggs on leaves of the mulberry tree.

(ii) Eggs

The eggs are round and yellowish-white, and they become grey as hatching time approaches.

iii) Larvae

The newly hatched larva is about 3 mm long and somewhat black in colour. The larvae grow in size and shed their skin (moult) four times. Each growing stage of the caterpillar consumes lot of mulberry leaves. The last stage full grown larva is about 7 cm long. It has a hump behind the head and a spine-like horn at the tail end. When full grown, the mature larva stops feeding, climbs on a twig and spins a cocoon.

(iv) Pupa

The full grown larva pupates inside the cocoon. In about 10 days time it transforms into a winged adult. The adult moth makes an opening in the cocoon and escapes through it.

The cocoon

The cocoon is formed from a secretion from two large silk glands (actually the salivary glands), which extend along the inside of the body and open through a common duct on the lower lip of the mouthparts. The larva moves the head from side to side very rapidly (about 65 times per minute) throwing out the secretion of the silk glands in the form of a thread. The secretion is a clear viscous fluid, which on exposure to the air gets hardened into the fine silk fibre.

The filament forming a cocoon is contineous and ranges in length from 700-1100 metres. The cocoons from which moths have emerged are called pierced cocoons. These are of low value because continuous thread cannot be obtained. Pieces are removed by instruments and spun into a thread.

Rearing of silkworms

Selected healthy silk moths are allowed to mate for 4 hours. Female moth is then kept in a dark plastic bed. She lays about 400 eggs in 24 hours, the female is taken out and is crushed and examined for any disease, only the certified disease- free eggs are reared for industrial purpose. The eggs are hatched in an incubator.

The hatched larvae are kept in trays inside a rearing house at a temperature of about 20°C-25°C . These are first fed on chopped mulberry leaves. After 4-5 days fresh leaves are provided. As the larvae grow, they are transferred to fresh leaves on clean trays, when fully grown they spin cocoons.

Reeling silk

The cocoons are cooked in hot water and the silk fibre is unwound from the cocoons. This process is called reeling. The silk consists of two proteins the inner core is fibroin and an outer cover of sericin. There are four following steps for the completion of the process of reeling:

For reeling silk the cocoons are gathered about 8 days after spinning had begun.

- The cocoons are first treated by steam or dry heat to kill the insect inside. This is necessary to prevent the destruction of the continuous fibre by the emergence of the moth.
- Next, the cocoons are soaked in hot water (95° -97°C) for 10-15 minutes to soften the gum that binds the silk threads together. This process is called cooking.
- The "cooked" cocoons are kept in hot water and the loose ends of the thread are caught by hand.
- Threads from several cocoons are wound together on wheels ("charakhas") to form the reels of raw silk.

Only about one-half of the silk of each cocoon is reelable, the remainder is used as a silk waste and formed into spun silk.

Raw silk thus obtained is processed through several treatments to give it the final shape.

Main properties of silk

1. It is lustrous, soft and strong.
2. It is made of two proteins: the inner core is fibroin and an outer cover is sericin
3. It is hard wearing.
4. It can be dyed into several colours

Silk moth *Bombyx mori* is at present fully domesticated. It no longer exists in a wild state and it cannot survive without the human care.

Silk Producing States of India

Major Indian States producing mulberry silk are: Karnataka, West Bengal, Jammu and Kashmir

Non-mulberry "silks"

1. Tasar silk is produced by certain species of another moth *Antherea royeli*. Their larvae are reared on Arjun trees, chiefly in Bihar, Madhya Pradesh and West Bengal.
2. Muga silk is obtained from *Antherea assama* whose larvae are reared on " Som" trees in Brahmaputra Valley.
3. Eri silk is produced by the moth *Philosamia ricini* whose larvae feed on castor leaves. It is produced in Assam.

Ex. No: 12 Date:

Silkworm Rearing House and Equipment

Rearing house and equipment

It is desirable to have a separate rearing house. Space requirement is minimum in shelf or stand rearing and maximum in floor rearing during old age rearing. Stand rearing is common in tropical countries. For a capacity of 200 to 250 dfls the features required can be provided in a 30' x 20' house with the following facilities.

1. Open verandah
2. Leaf room
3. Rearing hall & working space
4. Leaf inlet
5. Litter outlet
6. Two-step roofing
7. Exhaust
8. Air inlet
9. Wire mesh protected windows
10. False roof

Rearing Shed

Shed direction	: East to West
Windows direction	: North to South
Cross ventilation	: Keep wire mesh to windows, ventilators & doors to prevent entry of uzyflies.

Equipment for silkworm rearing

1. Rearing stands: These are made of wood or bamboo, portable and are 2.5 m high, 1.5 m long and 1 m wide with 10 shelves with a space of 20 cm between each shelf. The rearing trays are arranged in the shelves.

In whole shoot feeding method, rearing stand width should be 5 -5.5 ft. With One ft above the ground level.and with –2 ft. Distance between rearing stand & wall.

2. Ant wells: These are provided around the legs of stands to stop ants crawling on to the trays and attacking the worms. These are made of concrete stone base 20 cm^2 and 7.5 cm high with groove of 2.5 cm depth to hold water. The legs of the stands rest in the center of the block.

3. Rearing trays: These are used to rear silkworms and are made of bamboo. They are round (1.2 to 1.4 m dia) or rectangular (0.9 to 1.2 m x 0.7 to 0.9 m) with a depth of 7.5 cm.

4. Rectangular wooden trays or boxes: These are used for rearing early age larvae, made of light wood, size being 0.9 m x 0.7 m with a depth of 7.5 to 15 cm. About 8 boxes are required for 100 dfls.

5. Paraffin paper: It is a thick craft paper coated with paraffin. It is used for rearing early age worms, on the bottom and as a cover of the rearing bed to prevent withering of chopped leaves and to maintain humidity in the rearing bed.

6. Foam rubber strips: Long foam rubber strips of 2.5 cm wide and 2.5 cm thick dipped in water are used to keep all around silkworm rearing bed during first two instars to maintain humidity.

7. Chop sticks: These are made of bamboo, 17.5 - 20.0 cm long and thin and tapering to one end. A pair of chop sticks are used to pick early age larvae and also for preparing the bed.

8. Feathers: Bird feathers, preferably white ones are used for brushing the delicate newly hatched worms onto the rearing bed.

9. Chopping board: It is made of soft wood and used for cutting the mulberry leaf to suitable sizes and the size is 0.9 m x 0.9 m and 5 cm thick.

10. Chopping knives: These are used for cutting the mulberry leaves and are 0.3 to 0.5 m long with a broad knife blade and wooden handle.

11. Mats: Mats of 1.8 x 1.2 m are used for collecting the leaves when chopping is done on floor to prevent the dust and dirt on the floor getting mixed with the leaves.

12. Leaf chambers: These are maintained in rearing house for storing the harvested mulberry leaf ready for feeding the worms at set intervals.

13. Cleaning nets: These are made of cotton or nylon of different mesh sizes to suit the stage of the larvae. These are used for cleaning the rearing beds and at least two nets are required for each rearing tray.

14. Mountages: These are used as supports for the silkworms to spin cocoons and are made of bamboo, usually 1.8 x 1.2 m. Over a mat base tapes of 5-6 cm wide woven out of bamboo are fixed in the form of spirals with a gap of 5-6 cm in between (Chandrika).

Other equipment includes thermometers, hygrometers, feeding stands, feeding basins, sprayers, leaf baskets etc.

Disinfection and Hygiene:

The rearing house as well as the appliances used in rearing should be disinfected with 2% formalin prior to commencement of every rearing. For effective disinfection, the rearing house should be made air tight as far as possible and with the rearing appliances kept inside, the walls, windows, doors and the appliances should be sprayed with 2% formalin @ 7-8 lt for 100 sq mt and the doors closed immediately. After 24 hours of disinfection the doors and windows should be opened and the rearing house should be completely aerated at least 24 hours before the commencement of brushing.

QUESTION

1. **Draw any five silkworm rearing equipment with proper labels.**

Ex. No: 13 Date:

Mulberry Cultivation and Mulberry Varieties

Mulberry is a fast growing deciduous tree occurring in sub tropical and temperate climate. Mulberry has characteristic long idioblast cells in the upper epidermis of leaves. Inflorescence is a catkin/spike with unisexual flowers. Hence it is a cross pollinated crop. The important species of mulberry cultivated in India are:

a) *Morus alba*

b) *Morus indica*

c) *Morus bombycis.*

d) *Morus sinensis*

e) *Morus multicaulis.*

They belong to family Moraceae. The cultivation of mulberry is called as **Moriculture**.

Mulberry leaves:

- Silkworm prefers fresh, soft, succulent, smooth leaves with low fibre content.
- The three different kinds of factors influencing the feeding behaviour are:

a) Attracting factors

- Essential oils like citral, terpenyl acetate, linalol and –hexanol –excite the olfactory sensillae.

b) Biting factors

- Flavonoids like isoquercitrin and morin, terpenoids like -sitosterol and sugar like sucrose and inositol act on gustatory sensillae.

c) Swallowing factors

- Cellular supplementary mineral factors like potassium, dibasic phosphate, silica as well as inositol induce continuous feeding.

Composition of mulberry leaves:

Moisture 75-82%;	Crude fiber 9-11%; Crude
protein 24-56%;	Ash (minerals) 7-8%
Crude fat 3-4%;	Carbohydrate 12-20% and also rich in Vitamins

Soil:

Mulberry is a deep rooted, perennial, hardy crop. The quality of soil of mulberry garden influence not only the leaf yield, but also leaf quality, which in turn influences the growth and development of silkworm, subsequently the quantity and quality of cocoon production. The soil should be deep, fertile, well drained, clayey loam to loamy in nature, friable, porous with good moisture holding capacity. The pH of the soil should be around 6.2 to 6.8. Saline and alkaline soils are not preferred and need improvement through the use of soil amendments like gypsum, sulphur or green manuring *etc*

Climate:

Mulberry comes up well above 600-700 MSL. It can be grown in areas with rainfall of 600 mm to 2500 mm. Mean temperature of 24-28^{0}C, relative humidity of 65-80% are ideal for growth of mulberry. It can be grown with sunshine hours of 5.0-10.2 hrs/day in temperate conditions and 9.0-13.0 hrs/day under tropics.

Planting season:

Planting after the onset of monsoon is ideal under both rainfed and irrigated condition. Planting in winter and summer is to be avoided. Cuttings are to be planted either in north-south or east-west direction depending on sun shine hours and wind direction.

Land preparation:

The land should be tilled properly before planting to bring the soil to fine tilth. Land should be free from weeds and stubbles and leveled properly. FYM is to be incorporated @ 10 and 20 t/ ha for rainfed and irrigated crops, respectively as basal dose.

Preparation of planting material:

Mulberry can be propagated in two ways:

a) Sexual propagation by means of seedlings.

b) Asexual propagation by means of cuttings.

Propagation through cuttings is most common and widespread practice.

Shoots of proper maturity and thickness with active, well developed buds are chosen for cutting. The tips of tender branches and the bases of over matured branches are rejected. Branches with pencil thickness (10-12 mm dia) from 8-10 months old plants of desired variety are used for cuttings. The branches are cut into 18-20 cm (7-8”) long cuttings with a minimum of 3 internodes with well developed buds. The ends are cut clearly with sharp knife with no splits or peelings in the bark. The cuttings are placed in the nursery bed with about 2.5 cm of cutting with one node projecting above the soil. The cuttings are watered regularly. In ten days, the roots develop from buds in the internodes below the soil and the leaves from bud in the internode above the soil. The cuttings may be planted directly in fields or may be grown in nursery for 2-3 months and then transplanted.

Planting systems:

a) Row system:

It is followed under irrigated conditions. Ridges and furrows are made at 60 cm distance. Two cuttings are planted at each spot along the edges of ridges. The crop is grown as bush type.

b) Pit system:

It is followed under rainfed condition with wider spacing. Pits of 40 x 40 x 40 cm are dug and filled with 1 kg each of FYM, red soil and sand. Three cuttings are planted in a triangle in each pit. Spacing is 90 x 90 cm for bush type of cultivation. Wider spacing of 180 x 90 cm and 270 x 270 cm is adopted for high bush and tree plantation, respectively.

c) Kolar system:

It is nothing but row system with slight modification in spacing, followed in Kolar district of Karnataka. A spacing of 30-45 cm between the rows and 10-15 cm within the row is adopted.

d) Strip System:

It is followed in West Bengal and similar to Kolar system. Mulberry is grown in strips of 2-3 rows. Each strip is separated by a wide distance so that harvesting, inter cultivation etc. is easy. Within the strip distance between rows and between plants within the row is 15 cm.

e) Angular System:

Mostly followed in hill regions of Nilgiris. Distance between plants is similar to pit system *i.e.,* 90 cm. Plants in adjacent rows are planted in such a way they form a triangular shape. It allows more plants per unit area.

Table 13.1 Different recommended Varieties

Sl. No.	Situation	Varieties recommended
1.	Irrigated	Kanva-2, S36,RFS135, RFS175,V1
2.	Rainfed	S13, S34, AR11, Anantha
3.	Alkaline with pH up to 9.5	AR12
4.	Intercrop in coconut	Sahana
5.	Moisture stress and low input	RC-1
6.	Fertile soils with low input	RC-2
7.	Exclusively for chawki worms	G-2
8.	Exclusively for late age worms	G-4

Ex. No: 14 **Date:**

Study on Lac Culture

Lac is a resinous substance secreted by a tiny insect called *Kerria lacca* (popular name "lac insect")
Shellac is the purified lac usually prepared in the orange or yellow flakes.

Lac or shellac is used in many ways

- Commonest use is in polishing wooden furniture. The granules are dissolved in spirit and then are applied in very thin layers on the wooden surfaces
- In sealing parcels, packets and envelopes
- As insulating material in electrical work
- In making phonograph records (now replaced by synthetic material)
- In shoe polishes
- In toys and jewellery

Utilization of lac for various purposes has been very ancient in India. A "lac palace" is described in Mahabharata, which was intended to be used for burning the Pandavas alive.

Lac insect

The lac insect lives on native trees in India, Burma (now called Myanmar) and Malaysia. In India it is chiefly grown on trees like "Kusum", " Palas", and "Ber".

– The minute young lac insect (also called crawler) finds a suitable branch.

– The insect inserts its beak into the plant tissue to obtain nourishment.

– It grows in size and secretes a resinous material around itself.

– The resinous material hardens on exposure to air.

– Thousands of crawlers settle side by side and the resinous secretion builds up around them and completely encases the twig.

– Most crawlers develop in about 3 months into female which occupy small cavities in the resinous mass. The females can never come out of these masses.

– Eggs develop inside the body of the female and she assumes a sac like appearance.

– The female dies, the eggs hatch, the crawlers escape and move to a nearby-uninfected part of the twig, and the process is repeated.

Fig. 14.1 A piece of twig encrusted with lac

Extraction of lac

The encrusted twigs are known as **stick lac**. Such twigs are harvested.

- The stick lac is ground largely in crude mortars, and the resulting granular lac is called **seed lac**.
- The fine particles or the dust separated from the granular lac is used in making toys, bangles etc.
- The wood portion is used as fuel.
- The seed lac is washed, melted, spread out in a thin layer and dried. This is the shellac of commerce.

Earlier, the lac insects were found in great abundance in India and people directly or indirectly find livelihood in through lac culture.

Indian Institute of Natural Resins and Gums (IINRG), earlier known as Indian Lac Research Institute in Namkum, Ranchi conducts research on the various aspects of the lac insect. Synthetic lacquers have been produced by the modern industry, which is replacing true shellac for many purposes.

QUESTIONS:

1. What is the scientific name and family of the lac insect?

2. List any three common uses of lac.

Ex. No: 15 **Date:**

Lac Host Plants and Methods of Inoculation

Host plants:

1) Palas – *Butea monosperma* – Jharkhand, Chattisgarh, West Bengal
2) Kusum – *Schleichera oleosa* – Jharkhand, Chattisgarh
3) Ber – *Zizyphus mauritiana* – Jharkhand, Chattisgarh, W.Bengal
4) Ghont – *Zizyphus xylopyra* – Chattisgarh
5) Arhar – *Cajanus cajan* – Assam
6) Jalari – *Shorea talura* – Tamil Nadu
7) Raintree – *Samanea saman* – W. Bengal
8) Fig – *Ficus* species- Jharkhand, Punjab, Karnataka

Lac	Crop	Inoculation	Harvesting
Rangeeni	Rainy (*Katki*)	June- July	Oct –Nov
	Summer (*Baisakhi*)	Oct -Nov	June-July
Kusmi	Winter (*Aghani*)	June-July	Jan-Feb
	Summer (*Jethwi*)	Jan- Feb	June-July

Lac cultivation:

It is done by putting brood lac on suitably prepared specific host plants. The brood lac contains gravid females which are to lay eggs to give birth to young larvae. After emergence from mother cells, the young larvae settle on fresh twigs of host plants, suck the plant sap and grow to form encrustations.

a) Local practice:

In this method, the host plants are continuously exploited without giving rest for recoupment. Only natural inoculation occurs. Partial harvesting is done leaving few branches untouched for auto inoculation of next crop and no pruning is done. The host trees lose the vigour and cannot throw out new succulent shoots. In course of time, the trees become weak and die.

b) Improved practice:

The principle in improved practice is to provide much needed rest to host plants after harvest. For this, coupe system of lac cultivation is adopted. In this, the trees are divided into coupes *i.e.,* groups that consist certain number of trees. In practice, only few numbers of trees in a coupe are inoculated. After harvest, these trees are made to rest and recoup the last vigor while other trees are ready with succulent twigs for inoculation. Thus, in a coupe system, alternate groups of trees are put to lac cultivation. In case of slowly growing kusum, 18 months rest is given by dividing trees into 4 coupes and inoculating each coupe once in two years. In case of rangeeni hosts, trees are divided into 3 coupes *i.e.,* two large and one small in ratio of 3:1:3. The baisakhi crop is raised in 2 large coupes in alternate years. So that each coupe has a rest of 15 months in between and the katki crop is raised in small coupe every year allowing a rest period of 7 months between two successive crops.

Inoculation Methods, Cropping and Enemies of Lac Insect Inoculation Methods:
Propagation of lac insects is done by inoculation of newly hatched (brood) nymphs on the same or different host plants.

a) **Natural/self/auto inoculation:** This is a simple and common process, when the swarmed nymphs infest the same plant again. Natural inoculation, repeated on the same host, makes the host plant weak and thereby nymphs do not get proper nutrition. Uniform sequence of inoculation does not take place.

b) **Artificial inoculation:** The old weak and diseased twigs of host plants are pruned in January or June. It induces host plants to throw out new succulent twigs. The cut pieces of brood twig (*i.e.,* 20 x 30 cm in length) are tied to fresh twigs in such a way that each stick touches the tender branches at several places. The nymphs swarm from brood and migrate to tender and succulent twigs and infest them.

Following swarming, brood twigs should be removed from the host plant to prevent pest infestation.

Precautions for artificial inoculation:

a) Use fully matured and healthy brood
b) Don’t keep the brood meant for inoculation for long and use immediately after cutting.
c) Tie the brood stick on upper surface of branches securely.
d) Raise brood sticks at room temperature to 20^0C to induce swarming.
e) Avoid cultivation of rangeeni in kusumi area and vice versa.
f) Inoculate only on non rainy day.

Harvesting of lac (Cropping):

It is done by cutting the lac encrusted twigs when the crop is mature. It is of 2 types.

a) **Immature harvesting:** In this method, lac is collected before swarming. The lac, thus, obtained is known as "ARI LAC". In this method, lac insect may be damaged during harvest. Ari lac harvesting is recommended on Palas only.

b) **Mature harvesting:** In this method, lac is collected after swarming. The lac obtained is known as mature lac. Symptoms of swarming of nymph include the following.

a) A yellow spot develops on the posterior side of lac cell towards crop maturity.

b) Dried out appearance of encrustation two weeks before swarming and appearance of cracks on the encrustation at a later date.

Cutting of twigs for harvest can be done at any time between stages while yellow spot occupies one third to one half of the cell area. It is sometimes desirable to wait till the emergence of first few nymphs.

The kartiki crop is harvested in Oct/Nov, baisaki in May/June; aghani in Jan/Feb and Jethwi in June/July. The brood lac left after emergence of nymphs is known as stick lac or phunki lac.

Composition of lac:

Lac resin	: 68%
Lac wax	: 6%
Lac dye	: 1-2%
Others	: 25%

Lac processing:

1. Stick lac:

After harvest, lac encrustations are removed from the twigs of host plant by scraping. The raw lac thus obtained is known as **crude/scraped/stick lac**. The crude lac consists of resin, encrusted insect body, lac dye, sand and twig debris. The stick cannot be stored for long duration, as the lac has a tendency to form lump and there is a loss in quality of lac. High moisture content is responsible for lump formation. The optimum moisture content is 4% for storage of stick lac to avoid lump formation.

2. Seed lac/ grain lac:

The stick lac is crushed and sieved to remove sand and dust. It is then washed in large vats repeatedly to break open the encrusted insect bodies, to wash out the lac dye and twig debris. Decaying bug bodies turn the water a deep red that is processed further to get the byproduct, lac dye. The remaining resin is dried, winnowed and sieved to get the semi refined commercial variety product called seed lac. The seed lac is in the form of grain of 10 mesh or smaller and yellow/reddish brown in colour

3. **Shellac:** The seed lac is processed into shellac by any of the 3 methods: *i.e.*, handmade country process/heat process/solvent process.

Handmade process:

The seed lac is filled into long sausage shaped cloth of 2” diameter and 30 ft long. The long bag is passed gradually in front of a charcoal fired heat hot enough to melt the lac. By twisting the bag, molten lac is squeezed through cloth. The residue left inside cloth bag is another variety of refuse lac known as Kirilac. The molten filtered mass is stretched into sheets approximately 0.5 cm thick. Alternatively the molten mass is allowed to solidify in the form of discs and then it is called button lac.

Heat Process:

To the granular seed lac 4 -5 % resin and 2 -3% yellow pigment are added and the mixture is filled in cloth bags of about 3″long × 2″ in diameter The mixture is melted before the furnace in which charcoal is kept burning. The material is cooled inside and oozes out through the cloth and drops on the stone slab in front of the furnace. When sufficient amount has been collected on the stone slab, the molten mass is rapidly transferred to a porcelain cylinder containing hot water and spread flat with palmyrah leaves. This is again warmed before the furnace and stretched by men into a thin sheet with the help of his hands and feet. Defects like knots, air bubbles, etc are punched and removed out. This is broken into pieces and is known as shellac.

Solvent process:

The seed lac is dissolved in refrigerate alcohol and filtered through filter press to remove wax and impurities. The colour may be removed by any required standard by charging with activated carbon and then alcohol is recovered. The molten shellac is stretched with a roller.

4. **Button lac**:

It is manufactured by pouring the molten lac into dies in a zinc sheet instead of streching for shellac preparation. This results in buttons of lac 7 cm diameter and 0.6 cm thick.

Enemies of lac insect:

Include both predators and parasites and non insect pests like monkeys, squirrels, rats, birds and lizards.

Predators:

Larvae of *Eublema amabilis* (Noctuidae) and *Holcocera pulviria* (Gelichidae) are predators on lac both in field and store. Adult moths lay eggs on or near lac encrustation. The caterpillars bites its way into the encrustation and makes the tunnel lined with silk, excrete or pieces of lac in which it spends whole of its larval and pupal life. A single caterpillar *E. amabilis* can devour 40-45 lac cells.

H. pulviria is more severe in stores than in fields. Katki and Aghani crops are greatly affected than Baisaki and Jethwi crops.

Methods of Control:

a) Select brood lac from healthy trees.
b) Cut the brood lac from the trees as near the time of swarming, never more than a week before.
c) Remove the brood lac sticks immediately after two weeks of inoculation
d) Remove the lac sticks from field after harvest
e) Do not leave the crop in field for natural inoculation
f) Pack the brood lac in 30-60 mesh wire net before inoculation.

One to 20 kg of brood stick is necessary for inoculating a tree depending up on its size in case of kusumi strain, 0.4 to 5 kg in case of Rangeeni strain.

g) Heavier inoculation is not desirable as it may result in death of host tree.

h) The crawlers start moving out in one/two days after inoculation. The brood lac sticks are to be removed within three weeks of inoculation. Otherwise, the enemies of lac insect may be spread from broad lac to fresh crop.

Yield: About 2.5 to 3 times the weight of brood lac can be expected as yield

QUESTIONS

1. **What are the two strains of lac insect? Mention their time of inoculation and harvesting**

2. Write about the composition of lac?

3. Mention the different categories of potential enemies of lac insect.

Practical Manual

AGS-606

Crop Improvement-II (Rabi crops)

EXERCISE NO. 1

EMASCULATION AND HYBRIDIZATION TECHNIQUES IN WHEAT, OAT AND BARLEY

WHEAT

(*Triticum* species)

Family	**:**	Gramineae
Genus	**:**	Triticum
Species	**:**	*aestivum*
Chromosome Number	**:**	2n = 6x = 42

Cultivated Species

There are two cultivated species of wheat, viz. common wheat (*Triticum aestivum*) and durum wheat (*T. turgidum* L.). Common wheat is hexaploid (2n = 6x = 42), whereas durum wheat is tetraploid (2n = 4x = 28). The former is more widely adapted than the later. Common wheat is used for bread, cakes, noodles, cookies, chapatti etc., whereas the durum wheat is used mainly for macroni and some flat breads. There are 16 wild species of wheat, out of which six are diploids (2n = 2x = 14), seven tetraploids (2n = 4x = 28), and three hexaploids (2n = 6x = 42). Wild species are used in hybridization programme for transfer of resistance to biotic and abiotic factors, adaptation and other desirable characters into cultivated species.

Wild Species:

T. timopheevii
T. dicoccoides
Aegilops speltoides,
A. squarrosa.

Origin :

Near East is the center of origin of bread wheat. It is believed that evolution of common wheat in nature took place in two important steps. First, an amphidiploid tetraploid species originated from a cross between two diploid species, one with A genome and other with B genome. The amphidiploid after crossing with a diploid species with D genome gave birth to the common wheat as given below:

1	*Triticum monococcum*	X	*unknown diploid*	→	Tetraploid wheat
	(2n = 14, *AA*)		(2n = 14, *BB*)	→	(2n = 4x = 28, *AABB*)
2	Tetraploid wheat	X	*Triticum tauschii*	→	*Triticum aestivum*
	(2n = 4x = 28, *AABB*)		(2n = 14, *DD*)	→	(2n = 6x = 42, *AABBDD*)

The chromosome doubling took place in nature in above crosses. The other two forms of hexaploid wheat, viz. *T. compachim* and *T. spherococcum* originated through spontaneous mutations of *T. aestivum*. The durum wheat probably originated from cultivated emmer wheat (T. turgidum var dicoccum) after several spontaneous mutations.

Botany:

It is grown in *Rabi* season. It is annual plant growing up to height of 0.6 to 1.8 mts with adventitious roots. The stem is cylindrical culm with hollow internodes. Leaves are opposite with parallel venation. Leaf consists leaf sheath, blade, ligule and pair of auricles at the base of leaf blade. The uppermost leaf of plant is called flag leaf. Tillers are produced from the underground nodes by the axillary buds of the plant.

The inflorescence is of spike or ear type in which sessile spikelets are arranged acropetally in zig-zag manner on mother axis i.e. rachis. Each spikelet consists of pair of outer glumes which encloses 3 to 5 florets. Central one or two are sterile and remainingflorets are fertile. Each floret consists of outer glumes represented as scales, awned lemma (flowering glume) and a palea. The lemma and palea enclose three stamens (having thread like filaments and versatile anthers),single carpel (with bifid stigma) and two lodicules. The lodicules help for opening of flowers. After fertilization, ovary develops into caryopsis, which is a single seeded fruit with pericarp.

Crossing Technique:

Wheat is a self-pollinating crop. Flowering begins in the upper part of the spike and proceeds in both the directions. Flowering on a spike is over within 2-3 days. For emasculation roughly ¼ to 1/3 upper part of spike is clipped and a few basal, immature florets are removed. In the remaining 5-6 pairs of florets, the central florets are also removed and the emasculation is carried out in the remaining lateral florets of each spikelet. For this, glumes are clipped back and anthers are removed with fine pointed forceps. The emasculated spike is covered by a pollination bag. After 1-2 days, the stigmas are visible then the emasculated spike is covered by pollination bag. Thereafter in 1-2 days, the stigmas are visible and the emasculated spike is ready for pollination.

Pollination is done with the fresh pollen as pollen grains remain viable for a short period (1-3 minutes). For preparing male spike, a spike showing a few protruding anthers is removed from the male parent. Its glumes are cut without damaging the anthers. It is held in vertical position/stalk inserted in ground under sunlight for a few minutes. During thisprocess, anthers emerge out of cut glumes. The upper portion of the pollination bag on the emasculated spike is cut with scissors. Through this opening, the male spike shedding pollen is inserted and shaken over the emasculated spike by twirling motion and the bag is closed with the help of U clip. This simple and fast process of emasculation and pollination is commonly followed at most of wheat breeding stations.

Breeding objectives:

i) High grain yield.
ii) Early maturity with short duration.
iii) Photo and thermo-insensitive varieties.
iv) Resistant to diseases like rust, loose smut, leaf blight etc. and pests like aphids, armyworms and gujia weevil etc.
v) Responsive to high doses of fertilizers.
vi) Semi-dwarf varieties having synchronies productive tillers.
vii) Resistant to water logging and shattering.
viii) Good milling and baking quality i.e. suitable for chapatti and bread making.
ix) Amber grain colour and grain with high protein and lysine content.
x) Salt and drought tolerant varieties.

Breeding achievements:

1) Introduction: Sonora 64, Lerma rajo 64A, HI 977, Sonalika, Kalyansona Malvika
2) Pure line selection: NP 1,6,12, HB 208, K 852, Mondya 3-2, Motia, Gulab, Baxi-288-18,
3) Pedigree selection after hybridization:
   a) T. durum. N 59, MI 5749, Raj 1555, NIDW 15 (Panchwati)
   b) T. aestivum: NI 747-19, Lok 1, HD 2189, HD 2278, Prgato (DWR 39), NI-1917 (Kadwa)
4) Interspecific hybridisation
   a) T. durum x T. polonicum : MACS 9 (d)
   b) T. durum x T. dicoccum : Jay (d)
   c) T. durum x T. dicoccum x T. aestivum : Niphad 4
5) Interspecific hybridization and back crossing
   (*T. durum x T. aestivum*) : NP 890
6) Multiline varieties : NI 5439 Kharachiya 65
7) Mutation breeding: Pusa Lerma, Sharabti Sonora : NP 111, NP836

Improved varieties / Hybrids :

Sr. No.	Improved / Hybrid Varieties	Features
1	Godavari (NIDW-295) (*Triticum durum*)	Processing purpose, medium maturity (110-115 days), 18-20 qtl/acre productivity, best suitable for macroni making, protein content 12 %.
2	Tapovan (NIAW - 917) (*Triticum aestivum*)	Medium maturity (110-115 days), best for chapati making, protein content more than 12.5 %, high yielding variety under timely sown irrigated condition.
3.	Netravati (NIAW-1415) (*Triticum aestivum*)	105-110 days (Rainfed), best for chapati making
4.	Phule samadhan (NIAW-1994) (*Triticum aestivum*)	115-120 days, Bold size, best for chapati making, high yielding variety

Assignment :

1) Dissect the floral parts of given sample and mount them on black mounting paper. Draw the figures and label properly.
2) Practice hybridization technique in field and laboratory on given sample.

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OAT

(Avena sativa)

Family	:	Gramineae
Genus	:	*Avena*
Species	:	*sativa*
Chromosome No.	:	2n = 42

Oats are supposed to be of Asian origin and from there it spread to most of the countries of the world like USA, Russia, Canada, Poland, Australia, France and Germany.

Cultivated species :

The Oats are classified according to their chromosome numbers and there are three main groups of cultivated oats :

Group I :

This group of Oats contains 7 haploid chromosomes and the important of them are *Avena brevis* (short oats), *A. weistii* (desert oat), *A. strigosa* (sand oats) and *A. nudibrevis* (small naked seeded oats) etc.

Group II :

The oats belonging to this group contain 14 haploid chromosomes. The prominent types of this group are *Avena barbata* (slender oat), *A. absyssinica* (Absyssinian oats).

Group III :

These types have 21 haploid chromosomes and the important members of this group are *Avena fatua* (common wild oats), *A. sterilis* (wild red oats), *A. sativa* (common oats), *A. byzantina* (cultivated red oats) and *A. nude* (hull less oat).

Inflorescence :

Inflorescence of the oat plant is panicle composed of a central loose, open rachis with five to seven nodes, from which branches areas bearing spikelets. Each lateral branch terminates in a single apical spikelet. Other spikelet is born on second or third-order of branches. Each panicle may have 20 to 50 spikelets. Each spikelet consists of several florets enclosed in two empty glumes, with the tip of one glumes extending slightly above the other. Florets within each spikelet are arranged alternatively upon a central axis, the rachilla, and usually the two basal florets are fertile. The flowers are perfect zygomorphic, bracteates and hypogenous. The flower consists of a lemma and palea, two lodicules, three stamens and one pistil.

Spikelet :

Three to four florets are present in each spikelet, but the third or fourth floret is sterile, two glumes cover these florets.

Glumes :

The two outer bracts of the spikelet are broadly lanceolate, pointed boat shaped, usually labours and arched. The glumes may be pale, yellow or red.

Lemma :

Lemma is a rigid structure which enclosed the rachilla at the base of the flower. Its primary function is to protect the caryopsis. Lemma is bified and varies in colour, being white, yellow gray or red to black. It may be awn or awnless.

Palea :

One membranous palea is present opposite to lemma. Primary function of palea is to protect the caryopsis.

Lodicules :

Two small, smooth, pointed and shinning lodicules are present at the base inside the floret, mature lodicules are thick at the base and pointed at the tip. The action of the lodicules in opening the flowering glumes is not so important in self fertilized plants.

Androecium :

There are three stamens present. Stamens first appear as papillae upon the apex of the floral axis above the flowering glues primodia. The anther consists of four locules. The filament is attached to the central axis at its lower extremity.

Gynoecium :

There is one ovary with bifid stigma. The ovary is elliptical in cross section. Long monocellular, epidermal hairs entirely cover the ovary and also present on the interior surface and base of styles. The tip of style and the inner surface nearly to the base, are covered with stigmatic branches. A single sessile anatropous ovule is located inside the ovary.

Crossing Technique :

Emasculation :

Since anthesis normally occurs in the afternoon, emasculation should be done in late forenoon or early afternoon. Select those spikelet from a panicle in which anthesis is expected one or two days after emasculation. Keep only one floret within a spikelet. By applying light pressure on the dorsal glumes, separate glumes, palea and lemma and remove all the three anthers with the forceps. When emasculation is delayed until very shortly before the time of normal anthesis, the floral structure, being better developed will likely to be less injured by operation than they would be if manipulated a day or more before pollination. Cover the emasculated floret with a glassine bag to prevent contamination from foreign pollen and tagging is to be done.

Pollination :

Researchers have reported different time interval for pollinating the emasculatedfloret. Few reported optimum time between emasculation and pollination as one to threedays, while others suggested emasculating the floret in the morning and pollinating in the evening. Anthers from desired male parent are collected. The anthers will be yellow plump. Separate lemma and palea of emasculated floret and place the collected anthers with the help of forceps in the inner side of the lemma. Cover the pollinated floret with the same glassine bag used in emasculation. Approach method of pollination is also used in oats. In approach method remove secondary floret and the anthers of the primary floret. The upper portion of each spikelet, after emasculation is removed by clipping glumes, lemma and palea just above the stigma. The pollens from the male parent shed directly on the stigma of erect clipped spikelets.

Breeding objectives :

The broad objectives in breeding spring and winter varieties of oats are high grain yield, earliness, lodging and shattering resistance, disease resistance and quality. Winter hardiness and forage production are additional objectives in the breeding of winter oats.

1) Breeding for high yield.
2) Breeding for adaptability, salinity, water stress and temperature
3) Winter hardiness

Lodging and shattering resistance :

Oats must stand in the field until harvested, without loss either from lodging or shattering, if high yields are to be obtained.

Breeding for disease resistance

Several diseases have been reported on oat crop (Gupta *et. al.* 1998) causing considerable reduction in yield and deterioration in nutritive quality. Brief description of the some of the important disease is given below.

- Rusts
- Crown rust
- Stem rust
- Smuts
- Powdery mildew

Achievements :

Sr. No.	**Varieties**	**Features**
1	Kent	An introduction from U.S.A. which is resistant to rust, blight and lodging.
2	Algerian	It is an introduction from Algeria and is suitable for irrigated areas.
3	F OS-I/29	It is recommended for Punjab, U.P., Haryana and Delhi for irrigated and rainfed areas.
4	Brunker 10	It is suited to limited irrigated conditions and is resistant to loose smut.
5	Wetson 11	An early maturing and tall growing variety.
6	Coachman	An introduction from U.S.A. which is resistant to rust, blight and lodging.
7	HFO-114	A dual purpose variety recommended for Haryana
8	UPO-50	It is resistant to blight, rust and lodging and recommended for U.P.

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BARLEY

(Hordeum vulgare L.)

Botanical name	**:**	*Hordeum vulgare*
Family	:	Graminacae / Poaceae
Genus	:	*Hordeum*
Common name	:	Satu / Jav
Chromosome numbers	:	2n = 14

Fertility of the lateral spikelets forms the basis of barley classification and the cultivated barley may be classified into three main groups viz.,

i) Six rowed barley (*H. vulgare* L. emend, Lam)
ii) Two rowed barley (*H. distichum*, L. emend, Lam)
iii) Irregular barley (*H. irregular*, E. Aberg and Wiebe)

Botany :

The cultivated barley plant briefly consists of the following parts :

1) The roots, both seminal and permanent.
2) The stem (culm), cylindrical with hollow internodes, and from 5 to 7 solid nodes.
3) Leaves, borne alternatively on opposite sides of the stem and arising at each node.
4) The spike (head) at the top of the stem, consisting of the flowers arranged in spikelets, three of which are attached at each node of flat zig-zag rachis.
5) The spikelet, having two glumes and the floret.
6) The floret, consisting of the lemma and the palea, which enclose the male and female flower parts.
7) The kernel, consisting of the caryposis in naked barleys but including the lemma, the palea and the rachilla. Which adhere to the caryopsis, in hulled barleys (Reid and Wiebe, 1979).

Each spikelet is single flowered and consists of two glumes and a floret. In six-rowed barley, three spikelets are attached at each node of the rachis, and these triplets alternate from side to side of the rachis. In two rowed barely, only the central spikelet of a triplet is fertile. The flower is enclosed in lemma and palea. The pistil has a two branched feathery stigmas. Three anthers are attached to the long slender filaments. The spike of barely besides being characterized as six-row and two-row, is also described as hooded vs. awned. The hood is a three-lobed appendage at the tip of the lemma. The hood may be either slightly elevated on a short awn segment or sessile.

Crossing :

Flowering of barley spikelets begins in the central florets of the upper of the spike and proceeds in both the directions with the swelling of lodicules at the base of the florets, the flowers open and the filaments elongate. During elongation of the filament and emergence of the anthers, the dehiscence germinated five minutes after it reached the stigma, that within 10 minutes the two male gametes had entered the pollen tube. Within 40 minutes, the male gamete has reached the site of micropyle. Within 45 minutes, the male gamete had entered the egg sac. The first division of the fertilized egg completes five hours after pollination.

The emasculation is done in the early stage of the spike development when the spike is slightly visible through the covering of flag leaf. The upper 1/3 portion of the spike is removed. The emasculated spike is covered with butter paper bag. After 2-3 days, when the stigma is protruding. The spike is ready for pollination are carried out by twirling a spike with ripe with ripe anthers over the emasculated spike.

Breeding Objectives :

i) Yield improvement
ii) Increased adaptability
iii) Resistance to yellow rust, aphid and nematode
iv) Improvement in nutritional quality
v) Improvement in attributes related to malt industry

Achievements of Barley :

Sr. No.	Name	Parentage	Release year	Specific area of adaptation
1.	K603	K257/C135	2000	NEPZ
2.	BH393	California/ mariout	2001	Haryana
3.	NBBNOB(020)	Ratna K-425/Jyoti	2001	UP
4.	RD3592	RD2503/UBL9	2003	Rajastan
5.	K713	RD2540/BH407	2004	NEPZ

Improved Varieties / Hybrids :

Sr. No.	Varieties	Features
1	Ratna, Jyoti, Kailas	Hulled varieties
2	Karan-750, Amber, Himadri	Huskless varieties
3	C-138, RS-6, RD-57, RD-137, Clipper	Malting varieties
4	Karan 16, Karan 18, 19, Jyoti karan-3,4 Amber, Azad	Salt tolerant varieties
5	Kailash, Himani, Dolma, NP-100, NP-13, 21, 103	Suitable for hilly areas
6	Rajkiran	Nematode resistant variety
7	Nilam and Karan 19	Better chappati making quality for barley varieties

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EXERCISE NO. 2

EMASCULATION AND HYBRIDIZATION TECHNIQUES IN CHICKPEA AND LENTIL

CHICKPEA

(Cicer arietinum)

Family	**:**	Leguminoceae
Genus	**:**	*Cicer*
Species	**:**	*arietinum*
Chromosome Number	**:**	2n = 16

Cultivated species:

Related species : *C. reticulatum*
C. pinnatifidum
C. songaricum

Two main categories of Chickpea are recognized which are distinguished mainly by their seed characteristics. They are

1) Desi types, which are relatively smaller, angular seeds with rough yellow to brown coloured testas.
2) Kabuli types, with large, more rounded and cream coloured seeds.

Wild species :

The wild species of *Cicer* closely related to chickpea are :

i) *C. bijugum*
ii) *C. echinospermum*
iii) *C. ecticulatum*

Origin:

The chickpea is most probably originated in an area of present day south-eastern Turkey and adjoining Syria.

Botany:

Roots are robust and long. Stems are branched, flexuous or straight, erect to prostrate and usually ribbed. In general, height ranges from 20 to 100 cm. Three types of branching are defined. They are primary, secondary and teritiary branches. The leaves include rachis and leaflets. The average rachis length is 3-7 cm. Each rachis has on average 10-15 leaflets, inserted on small pedicels. The leaf is pseudoimparipinnate i.e., the ending terminal leaflet is not in true terminal position, but in sub terminal position (the central vein oblique to the rachis).

The flowers are papilionaceous. They are solitary in axillary racemes. Double flowers are rare, but are very much sought after by the breeders as possible sources of yield increase. The calyx has five deep lancelolate teeth. Peduncle and calyx are hairy. Generally, corolla is white. The vexillum is obovate, 8-11 mm long and 7-10 mm wide. Wings are obovate, 8-9 mm long. The keel is 6-8 mm long.

The androecium is diadelphous [(9) + 1]. The ovary is ovate, pubescent, 2-3 mm long, and 1-1.5 mm wide. It has 1-3 ovules, rarely 4. The style is 3-4 mm long, generally glabrous. The stigma is globose. Number of pods/plant is highly variable, generally between 30 and 150 depending on the year, location, sowing time and other factors. The seed is beaked, and very frequently ramhead shaped and strongy wrinkled or ribbed. Pod size has been found to be a stable charcter and based on this, two goups viz., macrocarpa and microcarpa have been postulated in *C. arietinum.*

Crossing Technique :

Crossing in chickpea is usually difficult and time consuming as is the case with most of the legumes. For emasculation, the bud is hold in left hand and gentle pressure is exerted to open the standard and wing petals. The keels are opened with forceps and the stamens are removed. Pollens are collected from half-open flowers and put on stigma. For better results, it is suggested that the crossing should be attempted after formation of first pod on the plant and as far as possible and large bud sized cultivars should be used as female parent. In Chickpea anthesis starts between 9 and 10 am and may continue up to 3 pm. The flowers remain open for two days, the flowering process over early on the second day. The plant is primarily self pollinated as anther dehiscence takes place forty hours prior to opening of flowers. The process of anther dehiscence prior to opening of flowers termed as cleistogamy has been recorded in the species.

Breeding Objectives :

(i) Increased seed yield.

(ii) Increased biomass, tall, erect and compact cultivars

(iii) Resistance to diseases

- (a) Ascochyta blight.
- (b) Fusarium wilt.
- (c) Root rot.
- (d) Botrytis grey mould

(iv) Resistance to insect pests:

- (a) Pod borer.

(v) Tolerance to stress environments:

- (a) Cold
- (b) Heat
- (c) Drought
- (d) Saline and alkaline soils.

(vi) Mechanical Harvesting

Improved Varieties / Hybrids :

Sr. No.	Varieties	Features
1	BDN-9-3	Early, wilt resistant, drought tolerant
2	BDNG-797	Early, wilt resistant and high yielding
3	Phule Vikrant	Yellowish brown, medium size seeds, wilt resistant
4	Phule Vikram	Tall growth habit, suitable for mechanical harvesting, medium size, yellowish brown seeds.
5	Himali	Extra bold seeded kabuli variety, wilt resistant
6	Kripa	Extra large seeded kabuli variety, milky white seed colour
7	Digvijay	High yield potential, bold seeds, wilt resistant
8	Rajas	Yellowish brown bold seeds, wilt resistant
9	Vihar	Extra bold seeded kabuli variety, wilt resistant
10	Virat	Extra bold seeded kabuli variety, wilt resistant
11	Vishal	Attractive yellowish brown bold seeds, wilt resistant
12	Vijay	High yield potential, wilt resistant, drought tolerant
13	BDNG-798	Kabuli, medium bold
14	Jaki-9218	Deshi, high yielding, wilt tolerant
15	ICCV 2	Early, kabuli type
16	Hirwa Chaffa (AKGS-1)	Green seeded, for rainfed and irrigated areas
17	PKV Harita	Wilt and drought tolerant, recommended for rainfed cultivation, green seeded.
18	PKV Kanchan	Wilt tolerant, recommended for irrigated condition for Vidharbha region
19	Gulak 1	Bold seeded, wilt tolerant, pink seeded, suitable for roasted purpose
20	PKV Kabuli- 4	Extra large seeded, kabuli, wilt tolerant, suitable for export purpose.

Assignment :

1) Dissect the floral parts of given sample and mount them on black mounting paper. Draw the figures and label properly.
2) Practice hybridization technique in field and laboratory on given sample.

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LENTIL

(*Lens culinaris* Medik)

Botanical name	**:**	*Lens esculenta* / *Lens culanaris*
Family	**:**	Leguminaceae
Sub family	**:**	Papilionaceae
Genus	**:**	*Lens*
Chromosome number:		2n=2x=14

Species :

The genus *Lens* Miler comprises five annual species of which only *L. culinaris* Medik (*L. esculenta* Moench) is cultivated.

Cultivated species :

L. culiaris Medik (*L. esculenta* Moench) is a characteristic component of the old World Belt of Mediterranean Agriculture. Numerous varieties of lentil are described. The cultivars are conventionally grouped in two inter-grading clusters – (i) small seeded lentils (sub-sp. *Microsperma* Barul) with small pods and small seeds (diameter 3-6mm), (ii) large seeded lentils (sub-sp. *Macrosperma* Barul), with large pods and with seeds attaining 6-9 mm.

Wild species. The four wild species are delicate, small flowered annuals distributed over South-West Asia and Mediterranean basin.

Botany :

The flower is typical papilionaceous, small, white, pale purple or purple blue. The corolla and specially the standard is broadly obovate and measures 4-6 mm long and 3-4 mm wide. The wing petals develop separately, rarely growing together with the keel petals. The keel petals enclose the pistil and the stamens. The style usually develops at a right angle to the ovary, and usually flattended on the outer side and trichoid on the inner side. The stamens are polyadelphous or diadelphous. The ovary is flat and non-pubescent and normally contains one to two ovules. The flower primordium is enclosed in a whorl of elongated, nearly calyx lobes. Pods are 1 -2 cm long, oblong, flattended, with curved beak and persistent calyx.

Crossing technique :

Lentil is strictly self-pollinated due to cleistogamy and dehiscence of anthers is before the flower opens. Wilson and Law (1972) reported less than 0.8% occasional cross- pollination through thrips or other small insects.

Wilson (1972) reported successful crossing in greenhouse. Crossing was best onyoung vigorous plants when the relative humidity was above 50% the nature between 15 and 25^{o}C in 12 – 15 hrs. of light and 9-12 hrs. of darkness. When the RH dropped below 35% the percentage of successful manual crosses decreased sharply. Lentil flowers continue to self- pollinate at the lower RHs, but pollen for crossing is difficult to gather transfer.

The buds (one half-three fourths the length of calyx lobes) are held between the thumb and the foreginger with the suture of the keel facing the operator. Special care is taken not to bend or twist the peduncle. Sharp-pointed forceps are used to carefully remove one or two calyx lobes nearest the suture side of the keel. The wings and keels are removed individually. The standard is either removed or folded and breaking them free from the stamina column or by pulling them outward. Manual pollinations are made immediately after emasculation. Pollen is selected from the vigorous flowers as soon after anther dehiscence as feasible. The keel is opened with forceps so that the stamina column and the pistil could be removed as a unit. This brush like unit is used to transfer pollen to the exposed stigma of emasculated flowers. The pollen laden pistil and the anthers are brushed against the trichoid side of the stigma. After pollen transfer the standard of the maternal flower is returned its original position around the pistil.

Breeding objectives :

1. High seed yield.
2. Bold seed size, high protein and less cooking time.
3. Early maturity.
4. Resistance to diseases :
   a. Ascochyta blight (*Ascochyta lentis* Bon – Mon. & Vass.)
   b. Rust (*Uromyces fabae* (Pers.) de Bary)
   c. Wilt (*Fusarium oxysporum* f. Sp. *Lentis* Vasd. & Srin. Gord).
5. Resistance to insects :
   a. Pod borer (*Etiella zinckenella Treit)*
   b. Cutworm (*Agrotis ipsilon* (Hfn.) *Ochropleura* (Agrotis) Flammatra (Schiff.)
   c. Aphid (*Aphs craccivora* Koch., A. *Gossypii* Gl., *Myzus persicae* (Sulz.)
6. Resistance to shattering
7. Tolerance to drought

Achievements :

Sr. No.	Varieties	Features
1	IPL-316	Brown with orange cotyledons and resistant to rust and moderately tolerant to wilt (Yield 16-18 q/ha)
2	IPL-81 (Noori)	Tolerant to rust and wilt, medium size seeds, early maturity (Yield 25-27 q/ha)
3	Pusa Lentil 5	Small seeded, orange cotyledon, resistant to rust
4.	Pusa Vaibhav	Small seeded, resistant to wilt and rust
5	Pusa Shivalik	Resistant to wilt and rust.

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EXERCISE NO. 3

EMASCULATION AND HYBRIDIZATION TECHNIQUES IN FIELD PEA, RAPESEED & MUSTARD

FIELD PEA

(Pisum sativum)

Family	**:**	Leguminoceae
Sub family	**:**	Papilionaceae
Genus	**:**	*Pisum*
Species	**:**	*sativum*
Chromosome number:		2n=14

Cultivated species :

Linnaeus distinguished two species within the genus *Pisum. Pisum arvense,* the coloured flower field-pea and *Pisum sativum,* the white flowered garden pea. Since then, following species have been designated.

1. *Pisum abyssinicum*
2. *P. aucheri*
3. *P. elatius*
4. *P. formosum*
5. *P. fulvum*
6. *P. humile*
7. *P. jomardi*
8. *P. transcaucasicum*

All forms of peas previously accorded species status (except *P. aucheri* and *P. formosum* which are tuber forming perennials and have been placed in genus *Alophotropsis* have a diploid chromosome number of 14 and cross among themselves readily. Therefore, they are now classified as ecotypes under *P. Arense* with white flowered garden pea considered as ecotype sativum. However, the widespread use of *P. sativum* to designate the garden pea would make it difficult to change this designation (Grittion, 1986).

Botany

The inflorescence is raceme arising from the axil of a leaf. The lowest node at which flower imitation occurs is quite constant under a given set of condition and is used in classifying the varieties with respect to flowering and fruiting duration. Most early cultivars produce the first flower from nodes 5 to 11 and the late cultivars start flowering at about nodes 13 to 15 (Gritton 1986).

The flowers are typical papilionaceous with green calyx comprising of five united sepals. Five petals (one standard, two wings and two keels). The stamens are in diadelphous (9+1) condition. Nine filaments are fused to form a staminal tube while the tenth is free throughout its length. The gynoecium is monocarpellary, with ovules (upto 13) alternately attached to the two placentas. Style normally bends at right angle to the ovary. Stigma is elliptical and sticky. Early cultivars are often single flowered or bear some single and some double flowers. Late cultivars are mostly double or triple flowered.

Crossing Technique :

Pea is strictly self-pollinated in nature. Stigma is receptive to pollen from several days prior to anthesis until 1 day or more after the flower wilts. Pollen is viable from the time anthers dehisce until several days thereafter.

For emasculation the plants to be selected should be vigorous and just beginning to flower. The flower bud chosen should have developed to the stage just before anther dehiscence, indicated by extension of petals beyond sepals. Flowers can be emasculated at any time. The first step in emasculation is to tear away with the flower and thumb in front and a light pressure is applied. This spreads the standard and wings to expose the keel. The exposed keel is slit-open by tips of forceps. Pressure can be applied by the thumb and finger on keel for increased exposure of the pistil and stamens. The 10 stamens are polled out.

Pollen can be obtained throughout the day, preferable from a freshly opened flower. For pollen collection, it is more convenient to pick the male flowers, remove the standard and wings, pull back the keel so that the style protrudes and use the pollen covered stylar brush as an applicator to transfer the pollen to the stigma of the emasculated bud. Older flowers and other flower buds not used in crossing are removed from the penduncle to increase the pod set after crossing (Gritton, 1986).

Breeding objectives :

Garden pea

1. High green pod yield
2. Long, attractive green pods with 9 – 11 seeds / pod
3. Sweetness
4. High shelling percentage
5. Specific maturity (early and medium)

Field pea

1. High grain yield
2. Bold, attractive seeds
3. Early maturity

Resistant to diseases

1. Downy mildew (*Peronospora viciae* (Berk) de Bary)
2. Powdery mildew (*Erysiphe polygoni* DC)
3. Rust (*Uromyces viciae – fabae* (Pers.) Schroet and *U. Pisi* (pers.) Wint.)
4. Wilt (*Fusarium oxyporum* Schl. F. Sp. *Pisi* (van Hall) Snyd. & Hans).

Resistance to insect

1. Leaf miner (*Phytomyza horticola* Gour (= atricornis)
2. Semi-looper (*Plusia ortichalea* Fb.)
3. Aphids (*Aphis cracivara Koch.*, A. *Gossypii* Gl.)
4. Pod-borer (*Etiella zinckenella* Trcit)
5. Pea stem fly (*Ophiomyia phaseoli* Tryon).

Important Achievements

Field pea varieties recommended for various states

State	Varieties
Uttar Pradesh	Adarsh, Vikas, Prakash, Rachana, KPMR400, Matar3, Pant Pea 42
Bihar	Rachna, HUDP15, VL42
Maharashtra	Adarsh, Vikas, Prakash, Rachana, Ambika, KPMR400
Rajasthan	Rachna, Hariyal, DDR27
Madhya Pradesh	Adarsh, Vikas, Prakash, Rachana, Ambika, KPMR400

Improved Varieties / Hybrids :

Sr. No.	Varieties	Features
1	IPFD 12-2	Resistant to powdery mildew, pod borer moderately resistant to aphids and leaf miner, Yield 22-25 q/ha
2	IPFD 11-5	Resistant to powdery mildew, and moderately resistant to pod borer, Yield 19-20 q/ha
3	IPFD 2014-2	Resistant to powdery mildew, Yield 22-23 q/ha
4.	IPF 99-25 (Adarsh)	Tall, Powdery mildew resistant, Yield 20-22 q/ha
5	IPFD 99-13 (Vikas)	Dwarf, Resistant to powdery mildew, Yield 22-25 q/ha
6	IPFD 1-10 (Prakash)	Large seeds, powdery mildew resistance, Yield 22-25 q/ha.
7	Pusa Prabhat (DDR-23)	Dwarf, Early maturity, powdery mildew resistant
8	Pusa Panna (DDR-27)	Dwarf, Early (90 days), Powdery mildew resistant
9	Rachana	Smooth round seeded, yield 15-20 q/ha.
10	Khaperkheda	Yield 10-12 q/ha, for irrigated condition.

Assignment :

1) Dissect the floral parts of given sample and mount them on black mounting paper. Draw the figures and label properly.
2) Practice hybridization technique in field and laboratory on given sample.

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RAPESEED AND MUSTARD

(*Brassica* species)

The chief features of rapeseed and mustard are as follows :

Sr. No.	Species	Common Name	Local Name
1	*Brussica junea* coss	Indian Mustard	Rai or Laha
2	*B. juncea* var. rugosa	Rugosa	Pahari rai
3	*B. nigra* Koch	Black mustard	Banarasi rai
4	*B. campestris* L. var. yellow mustard	Turnip rape	Yellow sarson
5	*B. comestris* L. var brown mustard	Turip rape	Yellow sareson
6	*B. campestris* L. var Toria	Indian rape	Toria or lahi
7	*B. alba; B. hirta* Moench	White mustard	Ujli sarson
8	*Eruca sativia* Mill.	Rocket cress	Taramira

Species	Chromosome Number
Brassica compestris sp. Olliefera	*2n=20*
Brassica juncea	*2n=36*
Brassica juncea	*2n=16*
Eruca sativa	*2n=22*
(B. nigra x B. oleracea)	*2n=34*
B. guncea *(B. nigra x B. compestris)*	*2n=36*
B. napus *B. oleraceae x B.compestris*	*2n=38*

Botany :

Brassicas have taproot system. Stem is succulent, straight and cylindrical. The leaves are pinnati divided. Whenever they exist, trichomes are always simple. Their presence or absence may be a good taxonomic character. A simple and well known example may be that of *B. oleracea*, *B. nigra* and *B. campestris* where the first is completed glabrous andthe two others hairy. The amphidiploids where one of the parents is *B. oleracea* (i.e. *B. carinata* and *B. napus*) are only very slightly hairy (Gomez Campo, 1980). The flower has typical cruciferae formula (K2 + 2, C4, A2 + 4, G (2)). The inflorescence is racemose and flowering is indeterminate beginning at the lowest bud on the main raceme. The syncarpous ovary develops into a pod (silique) with two carpels separated by a false septum.

Crossing technique :

The flowering is indeterminate and may last for two-three weeks. Stigma is receptive for about six days (three days prior to three days after the opening of the flower). The amphidiploids species (*B. Carinata*, *B. napus*, *B. juncea*) are self-compatible and self-pollinated in nature but about 30 % cross-pollination may occur by wind and insect under field conditions. The diploid species *viz.*, B. *nigra*, *B. aleracea and B. campestris* are self incompatible and consequently cross pollinated.

Selfing usually carried out by enclosing a flowering branch whose open flowers have been removed, in a muslin cloth bag in case of amphidiploids species – which are self compatible. In case of self – incompatible diploid species, selfing is done mostly by bud-pollination. In bud pollination, a flowering branch whose open flowers / young pods have been removed, is bagged by muslin cloth bag. After a few days, the bag is removed temporarily and pollen from freshly opened flowers is applied on the stigma of young buds which are preferably emasculated. The self incompatibility in Brassica is of sporophytic-homomorphic type under monofactorial polyallelic series where pollen is inhabited on the stigma. Various techniques available for obtaining a temporary break down of the self-incompatibility character are as follows (De Nettancourt, 1972).

1. Bud pollination
2. Delayed self pollination
3. Grafting
4. Heat shocks
5. Application of carbon dioxide
6. Hormones and protein inhibitors
7. Chronic irradiation
8. Acute irradiation of styles
9. Acute irradiation of pollen mother cells
10. Tetraploidization – haploidization
11. Haploidization – diploidization.

Permanent self –compatibility can be induced by

1. Mutation of S locus
2. Modification of the genetic background
3. Tetraploidization

Breeding objectives

1. High yield
2. Early maturity
3. High oil
4. Low erucic acid and glucosinolates
5. Resistance to diseases
    a. *Alternaria* blight (*Alternaria brassicae)*
    b. White rust (*Albugo candida)*
    c. Downy mildew (*Pernospora parasitica)*
    d. Sclerotinia rot (*Sclerotinia sclerotiorum)*
6. Resistance to insects
    a. Aphids (*Lipaphis erysimi)*

Achievements in Rapeseed / Mustard :

1) Mustard : Varuna (T-59), TM2, TM4, Seetha
2) Brown sarson : KNS3, KOS-1
3) Yellow sarson : Pusa gold, YS-93
4) Toria : Jawahar Toria, Panchali, TS-29
5) Taramira : RTM-13, TMC-1.
6) Pusa Jai Kisan (Bio-902) : First somaclonal variety in 1993
7) First hybrid variety of PGSH-51 of Sobhi sarson
8) Frost resistant RH-781
9) White rust resistant varieties RH-813
10) NRC Sankar Sarson (NRCHB-506) & (JM-1) through heterosis breeding using moricandia cytoplasmic genetic male sterility system
11) Shabadi : 95-105 days duration, Blackish red, 8-12 q/ha yield, 32-40 oil percentage
12) NRCHB-101: 10-115 days duration, Blackish, 8-10 q/ha yield, 35-42 oil percentage
13) Bio-902 : 99-110 days duration, Blackish red, 6-10 q/ha yield, 39-41 oil percentage
14) Pusa mustard 27 : 118 days duration, Suitable for multiple cropping system, tolerant, 41.7 oil percentage, 1.53 t/ha yield.

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EXERCISE NO. 4

EMASCULATION AND HYBRIDIZATION TECHNIQUES IN SUNFLOWER

SUNFLOWER

(*Helianthus annus)*

Botanical name	**:**	*Helianthus annus*
Family	**:**	Compositae
Genus	**:**	*Helianthus*
Species	**:**	*H. annus* *H. tuberosus*
Chromosome No.	**:**	2n = 2x = 34

Cultivated species :

Sunflower (*Helianthus annus*, 2n=2x=34) is an important oilseed crop after soybean and palm in the world and accounts for about 12.8% of the world production of edible oil. Its oil content ranges from 46 to 52% and is of high quality having non-cholesterol and anticholesterol properties.

The genus *Helianthus* comprises 67 species native to the Americas. Two species, *H. annuus and H. tuberosus* are cultivated as food plants and several species are grown as ornamentals. *H. annuus*, the common sunflower cultivated for oil is diploid (2n=34) and *H. tuberosus* is haxaploid (2n=102) and is cultivated for tubers.

Wild relatives :

H. decapitulus
H. rigids
H. annus sub spp. *annus*
H. annus sub spp. *lenticularis*
H. annus sub spp. *jaegeri*

Botany : The inflorescence is a capitulum or head, characteristic of composite family. The number of flowers in oilseed cultivars may vary from 700 to 3000. The flower of the outer whorl of the head are called as ray florets. They have five elongated petals which are united to form straplike structures. They have vestigeal styles and stigmas and no anthers. The other flowers arranged in concentric rings over the remainder of the head are called as disc flowers. Each disc flower consists of a sharp pointed chaffy bract, a basal inferior ovary, two pappus scales (often considered to be modified sepals), a tubular corolla of five petals which are united except for the tips. Five anthers are united to form a tube with separate filament attached to the base of the corolla tube. Inside the anther tube, there is the style, terminatingin a stigma which is divided. The receptive surfaces of stigma remain in close contact in bud stage. The achene or the fruit of the sunflower consists of a seed often called the kernel. The adhering pericarp is usually called the hull. The seed consists of seed coat, endosperm and embryo. Major part of embryo is in the form of cotyledons (Knowles., 1978).

Crossing technique :

Sunflower is highly cross pollinated crop mainly through insects and to a limited extent by wind. The flower opening starts from outer side of the head and proceeds towards centre of the head, the heads bloom within 5-10 days depending upon size and season. Anthesis occurs between 5 to 8 AM. The pollen grain viability lasts for 12 hours. The stigma remains receptive for two-three days. Selfing is done by bagging of the head. The bagging material could be cotton cloth, tiffany bags or paper bags or cheese cloth bags or plastic netting. Emasculation is done as follows :

Hand emasculation :

Emasculation is done by removing the anther tubes with forceps early on the morning that the flowers open. Unemasculated flowers are removed.

Without emasculation :

Considering hand emasculation tedious, sometimes crosses are made without emasculation. Hybrid plants are distinguished from selfed ones on the basis of vigour or the presence of marker genes.

Chemical induction of male sterility :

This is achieved by spraying of 0.5-1.5 mg of a 0.005% solution of gibberellic acid/plants are distinguished from selfed ones on the basis of vigour or the presence of marker genes.

Pollination :

Pollination is carried out by collecting pollen from heads which are already bagged prior to flowering. Pollen can be collected from flowering heads into paper bags by a light tap of the hand on the back of the head. Pollination is usually done in the same morning after emasculation. Pollen can be applied by a small piece of cotton, a camel hair brush, the corner of the cloth bag isolator, a small section of leaf, paper or other suitable material that is dipped in the pollen and gently drawn over the receptive surface of the stigmas. Freshly collected pollens are more effective in pollination. Pollen can be stored without serious loss ofviability for 1-2 weeks in cork-stoppered vials at ordinary room temperature. After each cross, care must be taken to avoid contamination by wiping the hands with alcohol and cleaning or discarding the pollen applicator (Fick, 1978).

Breeding objectives :

i) High seed yield

ii) Early maturity

iii) Lodging resistant dwarf plant type

iv) Uniformity of plant type

v) High oil percentage

vi) Tolerance to stress conditions

vii) Resistance to bird damage

viii) Resistance to diseases : Flowing diseases are serious in India.

a) Leaf spots (*Alternaria helianthi*, *Cladosporium cladosporoides*)

b) Rust (*Puccinia helianthi*)

c) Root rot and damping of (*Sclerotium rolfsii*, *Rhzoctonia bataticola*, Syn. *Macrophomina phaseolina*)

d) Stem rot (*Sclerotinia sclerotiorum*)

e) Head rot (*Rhizopus* spp.)

f) Powdery milder (*Erysiphe cichoracearum*)

ix) Resistance to insect-pests :

a) Head damaging pest (*Heliothis armigera*)
b) Grass hoppers (*Chrotogonous* spp.)
c) Jassids (*Amrasca bigutulla*)
d) Leaf eating caterpillars (*Diacricia oblique*, *Spodoptera litura*, *Plusia orichalcea*).

Achievements :

Open-Pollinated varieties and hybrids of sunflower evolved / released

Variety / hybrid	States for which recommended	Seed yield (Kg/ha) in rainfed areas	Oil content (%)
Variety			
Morden	All states	600-800	36-38
EC 68414	All states	800-1,000	40-42
EC 68415	Karnataka	800-1,000	40-42
Surya	Maharashtra	800-1,000	32-35
CO 1	Tamil Nadu	500-700	38-39
CO 2	Tamil Nadu	800-1,000	38-40
TNAU-SUF 7	All States	800-1,200	38-42
GAU-SUF 15	Gujarat	800-1,200	38-42
SS 56	Maharashtra	700-900	36-38
Hybrid			
BSH	All states	1,000-1,500	40-42
KBSH 1	All states	1,200-1,500	42-44
KBSH 11	All states	1,000-1,500	40-42
LSH 1	Maharashtra	900-1,200	37-39
LSH 3	Maharashtra	1,000-1,500	38-40
PSFH 67	Punjab	1,000-1,500	40-42
PKVSH 27	Maharashtra	900-1,100	38-40

Improved Varieties / Hybrids :

Sr. No.	Varieties	Features
1	LSH-1	Downy mildew resistant, rainfed
2	LSH-2	Downy mildew resistant, rainfed
3.	LS-11	High yielding having high oil content
4.	SS-56	Suitable for rainfed conditions, oil content 32-35 %
5.	Bhanu	Tolerant to drought, oil content 35-36 %
6	Phule Raviraj (Hybrid)	Oil content 34 %, big head size with central filling head, tolerant to bud necrosis and alternaria
7	Bhaskar	Early maturing, high yield, oil content 37-38 %, dark black shiny seeds.
8	PKVSH952	92-95 days duration, Black seeded, 38-40 % oil (seeds), with 15-18 q/ha yield potential.

EXERCISE NO. 5

EMASCULATION AND HYBRIDIZATION TECHNIQUES IN POTATO AND BERSEEM

POTATO

(Solanum tuberosum)

Botanical name	**:**	*Solanum tuberosum*
Family	**:**	Solanaceae
Genus	**:**	*Solanum*
Chromosome no.	**:**	2n = 4x = 48

Cultivated species :

Potato is the most useful and important member of the family Solanaceae and it belongs to genus *Solanum*. Genus *Solanum* consists of seven cultivated and about 154 wild species but the commercially viable potato has only two species :

1) Solanum andigenum :

The plants of this species are characterised with thin and long stems, small and narrow leaflets having profuse flowering and long stolons. The tubers are mostly covered with deep sunken eyes on them. The yielding potential is very low and therefore, it is not very common type.

2) Solanum tuberosum :

The potato cultivated the world over is an autotetraploid species, *S. tuberosum*. This species is divided into two sub species viz. ssp. tuberosum (cultivated throughout the world) and spp. andigena (confined to the hills of South America). In addition, diploid (2n=24), triploid (2n=36) and pentaploid (2n=60) forms are also cultivated in Peru and Bolivia.

3) *Solanum demissum* and *Solanum stenotonum* are two more species which are somewhat important as they are resistant to some types of virus and disease but they are also not in cultivation commercially.

Flowering in potato :

The potato requires long day lengths (around 16 h), abundant rainfall, and cool temperature to flower. Under most normal growing conditions, the day length in the early part of the season will favour constriction of the stem, and grafting of young potato shoots onto tomato or other compatible *Salanaceous* plants. Among the cultivars currently used for breeding, selecting for increased flowering and seed set does not cause reduced tuber yield. Flowering and tuber yield are uncorrelated as are berry or seed set and tuber yield.

Crossing Techniques :

Flower buds that are mature are selected for emasculation just prior to crossing. It is particularly important to emasculate just prior to crossing if pollinations are done in the fields the wind can break off the stigmas before pollination occurs if they are emasculated too far ahead of pollination. Mature buds are plump, with the petals ready to separate. The remaining buds and opened flowers in the bunch are removed to facilitate emasculation of the selected buds and prevent contamination of the emasculated flowers by the open flowers. There is a limit to the number of flowers from an inflorescence that will set fruit / seed, so removing the extra flowers increases the chances that the pollination will be successful. The petals of the selected flowers are gently pushed apart along the sutures and the five stamens removed with fine-pointed forceps without breaking the style. The emasculated flowers are then bagged.

Inserting a branch with one or two leaves into the bag helps in maintaining a humid climate inside the bag. In fully self-sterile parents, emasculation is unnecessary.

Pollination can be done at any time of the day as long as the temperature is not too high. Open flowers are collected from the plant to be used as a male. The flowers are laid out to dry overnight. The following morning the pollen is collected from them by shaking into gelatine capsules such as those used in the pharmaceutical industry (other small tubes canalso be used). For large quantities of flowers, the pollen is shaken out by placing the flowers in the top section of a sieve, and the sieve is then shaken at high speed. The pollen falls through and is collected in the smaller capsules or tubes for storage. For smaller quantities of flowers, a modified toothbrush or doorbell buzzer is used to vibrate the pollen free. The flowers are inverted over glassine paper and the vibrating portion of the toothbrush or buzzer is touched to the anthers. The pollen falls onto the slick paper and is then transferred into the capsules or tubes. Pollen can be stored desiccated in the refrigerator for 1 – 2 weeks and in the freezer for 6 months to a year. To make the pollination, the stigma is dipped in the pollen in the capsule or tube, and then the pollination tag is attached and the bag is placed over the flower and left on until the fruit is harvested. Setting of seed may be observed in about 7 – 10 days. Average seed set per berry varies with the cultivar, but levels of 50 – 200 seed per fruit maybe obtained.

Breeding objectives of potato

1. Tuber yield
2. Maturity
3. Heat, frost and drought resistance.

Breeding for disease / pest resistance

1. Root knot nematode
2. Aphids are serious
3. Colorado potato beetle.

Breeding for improved quality

Potatoes are either consumed directly or they are processed. The amount of potatoes used for processing is increasing. Processed potatoes have various uses, including being used in the fast-food industry, made into snacks, used as a starch source, and for alcohol production, among other uses. High quality is an important breeding objective because it has direct relationships to consumer acceptance higher premium in the marketplace. Some of the desirable feature of high tuber quality include good keeping quality, medium size, good grading, good shape, proper colour, no cracks, flatness of the eyes, and proper skin texture, among others. Cultivars differ markedly in the ability to be stored. Thick-skinned potatoes have better keeping qualities than thin-skinned potatoes. Keeping quality is associated with non-sprouting and resistance to storage diseases. Cultivars differ in their cooking qualities, some requiring prolonged cooking, while others cook easily. Freedom from after-cooking darkening is also desirable. White tubers are preferred to red ones and they sell at higher prices in most markets.

True potato seed

Breeders have long sought to increase potatoes by seed. The production of potato from true potato seed (TPS) has several advantages compared to tubers, including.

- Production of virus free stocks as viruses are generally not transmitted by seed.
- Reduce storage problems because refrigeration of TPS is not necessary.

- Lower shipping costs for TPS.
- Easier shipping of TPS because 100 g TPS will seed a hectare while 2,000 kg of seed tubers are needed to seed the same area and
- Consumption of all tubers produced, as none need to be saved for next years seed crop.

The objective of TPS is to have completed homogeneous progeny. This can best be accomplished by the use of 4*x* families from 4*x* x 2*n* crosses, where the 2*x* parent produces 2*n* gametes. It is important that both parents be adapted to the area where the homogenous progeny are going to be grown. Studies have shown that higher seeding vigour and tuber yields resulted from this approach compared to progeny produced from 4 *x* x 4*x* crosses or progeny obtained from open pollinated seed.

Improved Varieties / Hybrids :

Variety	Year of release	Salient features and adaptability
Kufri Chipsona 1	1997	Medium-maturing, resistant to late blight and excellent for processing, North India plains
Kufri Chipsona 2	1997	Medium-maturing, resistant to late blight and excellent for processing, Uttar Pradesh and Bihar
Kufri Giriraj	1997	Medium to late maturing and resistant to late blight, North western hills
HT/92-61	2003	Hybrid, heat tolerant, resistant to leaf hopper and mites, high dry matter content, suitable for making French-fries
JW160	2003	White hybrid, having field resistance to late blight, excellent keeping quality
MS/92-2105	2003	Red skinned, high-yielding hybrid, oval attractive tubers, field resistance to late blight
SM/87-185	2003	Late-blight resistant, white tuber hybrid with high dry matter content and better keeping quality

BERSEEM

(Trifolium alexandrium)

Botanical name	:	*Trifolium alexandrium*
Family	:	Leguminosae
Genus	:	*Trifolium*
Sub-family	:	Faboideae
Chromosome No.	:	2n = 16

Cultivated species :

Berseem, known as king of fodder crops, is popular among livestock farmers of the world. It belongs to the clover group and internationally famous as Egyptian Clover. Botanically it is known as *Trifolium alexandrinum* L. Berseem is one of the oldest cultivated clovers, domesticated in Egypt and later introduced into many other parts of the world. Berseem belongs to the family leguminosae and genus *Trifolium* which consists of nearly 290species as most important forage legumes. The most important species for forage and pastureare berseem (*Trifolium alexandium*), Shaftal (*T. resupinatum*), White clover (*T. repens*), Red clover (*T. pratense*), Crimson clover (*T. incarnatum*), Alsike clover (*T. hybridum*) and Subterraneum clover (*T. subterraneum*) etc.

Origin :

Berseem is believed to be originated in Asia minor and from there it was introduced to Egypt. Because of its introduction from Egypt it is famous as Egyptian clover and it is gaining its increasingly importance as *rabi* crop.

Berseem doesn't have original wild forms.

Botany :

It is a fast growing annual crop with 30-60 cm plant height. The stem is hollow and succulent. Both basal and /or stem branching is observed. Roots do not extend beyond two feet in general and contains nodules. It is sparingly hairy and commonly possess trifoliate, petiolate leaves. Leaves are membranous, oblong-elliptical to oblong-lanceolate and are arranged alternately except the uppermost leaf. Leaflets are mucronate at the apex anddenticulate in. Inflorescence is head, terminally or auxiliary located and pedunculate with conical to ovoid in shape. There is a small involucre at the base of the head. Calyx tube displays ten prominent nerves while the corolla is almost double the height of the calyx. Eachinflorescence contains around 100 papilionaceous flowers, white in colour with around 1cm length. At maturity each floret contains one single seed. Seeds are solitary and small in size. Seed is egg shaped, yellowish in colour and is of around 2mm in length. In berseem white coloured flowers are produced in cluster which are hermaphrodite in nature with five fused sepals and five free petals. The upper large petal which covers the rest of the petals in bud stage is called standard petal, while two bottom petals are fused together and formed a boat- like structure called the keel. The stamens are always ten in number and their filaments are fused in a group of 9+1. Berseem is a cross pollinated plant and is entomophilous in nature. Anthesis occurs in the morning hours which coincides with maximum pollinator activity, leads to seed setting.

Based on regeneration capacity and branching pattern three different ecotypes viz., Mescavi, Fahli and Saidi are reported in berseem. The mescavi type has very good regeneration potential and is capable of 5-6 cuts with basal or crown branching pattern and is the most popular type with large number of varieties in India belong to this group. Fahli is a stem branching type with low regeneration potential and is suitable for single cut only. Saidi is having moderate regeneration capacity allowing 2-3 cuts and possess both basal and stem branching.

Achievements:

Sr. No.	Variety	Features
1	Mescavi	Varieties under this group develop short side branches at the base of the stem in advanced stage of its growth. When the plantis cut or harvested, these branches elongate and produce new growth. Therefore, it is possible to take 5-6 cuts per year from this group. Varieties : Wardan, JB-1, JB-2, JB-3, UPB-103
2	Fahl	Develop small side branches in the upper portion of the stem very freely. They do not produce branches at the base. Therefore, there is no regeneration of these varieties after harvest. They give only one cut.
3	Saidi	They develop shoots for a short time. Develops branches at upper portion less freely than in fahl. They give 2-3 cuts per year. Varieties :Khandwari, Pusa giant, ICFRI-99-1, IGFRI-54, Jawahar.

Diploid varieties like Meskavi, Fahali, Sauidi, Zaidi, BL-1, BL-2, BL-10, BL-22, BL-30, BL-92, JB-3, JB-4, IGFRI-S-99-1, UPB-101, UPB-103, UPB-104, UPB-1905, and Khadrabi are very popular but newly evolved high yielding tetraploid varieties like Pusa Giant, T-526, T-724, T-780, T-529, T-560, T-561, T-674, T-678, T-730 etc. are very promising and give about 50 per cent higher fodder yield.

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EXERCISE NO. 6

EMASCULATION AND HYBRIDIZATION TECHNIQUES IN SUGARCANE AND COWPEA

SUGARCANE

(*Saccharum spp.)*

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Family: Gramineae
Genus: Saccharum

Cultivated species :

There are three cultivated and two wild species of sugarcane. Their brief description is a follows (Rao *et. al.* 1983; Purseglove, 1988).

1. *Saccharum officinarum (2n = 8x = 80)*
2. *Saccharum barberi (2 n =90,92)*
3. *Saccharum sinense (2n = 116, 118).*

Wild species :

1. *Saccharum spontaneum (2n = 40 to 128).*
2. *Saccharum robustum* (2n = 60 to 194).

Botany :

Induction of flowering. Lack of flower induction and synchronization are barriers in sugarcane crossing programme. Flowering of sugarcane is rare in subtropics. Experiments of photoperiod requirements have indicated that sugarcane can be classified as intermediate day length plant (IDP) on the basis of initial induction and as short day plant (SDP) based on the development of the panicle and flowers. A dark period around 12.30 hr in general, has been found necessary for induction of flowering. Sites have been identified in India, Brazil, Barbados, Hawaii, Fiji, Indonesia and Philippines where most clones of sugarcane flower. In India Coimbatore has been chosen as the ideal place for natural profuse flowering and good seed setting in sugarcane clones. In varieties difficult to flower, exposing the plants to 4 hr extra- darkness in continuation of normal night for 6 – 8 weeks at the transformation stages has been found effective (Rao *et. al.* 1983). Synchronization of flowering between early and late flowering varieties is possible by manipulation of 4 hr extra darkness and 4 hr extra light.

Floral biology :

The inflorescence of sugarcane is an open, branched panicle and is called as an arrow due to its shape which is like an arrow. Flowering is seasonal and takes place when the day length decreases. In the northern hemisphere the flowering coincides with the onset of winter (Oct.-Nov.) and in the southern-hemisphere in May-June.

The spikelets open about sunrise, beginning at the top of the panicle and proceeding downwards and from the tips of the branches inwards, over a period of 5 – 15 days. Approximately1/6 to 1/10th of the panicle opens each day. The swelling of the lodicules by water uptake causes the glumes to be pushed apart and the stigmas come out. The anthers dehisce about three hours after the elongation of the filaments. High humidity delays an thesis. Natural pollination is by wind.

Crossing techniques : Following techniques are used to facilitate convenient handing of the parents.

Stalk preservation during crossing :

The sulphurous acid technique is in generally use by sugarcane breeders. A sulphurous acid solution (1 part in 2000) keeps the inflorescence alive for several weeks. At the Hawaiian Sugarcane Planters Association (HSPA) Experiment Station, the solution used consists of 150 ppm SO_2, 75ppm H_3PO_4 and 375 ppm each of H_2SO_4 and HNO_3 **(**Heinz and Tew, 1987).

Marcotting :

It was first used in India and now is used in many countries. Generally, a plastic sleeve containing a growth medium is secured about five to ten nodes above the bas of the stalk to induce rooting.

Potted plants :

For clones and species not responding to the sulphurs acid technique or marcotting, the sugarcane clones are grown in small containers.

Crossing in field :

This system is common in India. Pollen proof enclosures made of cloth (cloth lanterns) are used to cover the arrow of female and male parent before anthesis. Male arrow (which is also protected) is introduced into this lantern and it is shaken for 5 – 6 days once ina day.

The crossing may be done either with the arrows attached to the parent plants or with the arrows severed and transported to a central crossing area and maintained in living condition by means indicated above. Female and male arrows can be enclosed in a common lantern if they are planted close to each other.

Breeding objectives :

1. High cane yield.
2. Moderate high sucrose content
3. Early to full season maturity
4. Resistance to diseases.
   a. Red rot (*Physalospora tucumanesis)*
   b. Smut (*Ustilago scitaminea Sydow).*
   c. Wilt (*Cephalsporium sacchari* Butler)
   d. Mosaic (a viral disease)
   e. Ratoon-stunting disease (caused by a bacteria)
   f. Grassy – shoot disease
5. Resistance / tolerance to insect pests
   a. Shoot borer
   b. Cane borer
   c. Pyrilla
   d. Mealy bugs
   e. Whiteflies
   f. Termites
   g. White grub
6. Tolerance to Aboitic stresses
   a. Drought
   b. Salinity
   c. Flooding
   d. High temperature

Achievement :

i) Sugarcane breeding institute has been the source of germplasm and genetic variability for selection of varieties suited to different agro-climatic zones of the country. The spread of Co canes to foreign countries began when Co 285 was taken to Cuba and USA (Florida) for cultivation. Varieties bred at Coimbatore are / were being used in 28 other countries either for commercial cultivation or as parents. Co 419 released in 1933 became the most popular variety in tropical India and was rightly hailed as the wonder cane the world over.

ii) Two outstanding varieties viz., Co 658 for Tamil Nadu and Co 740 for Maharashtra were released in 1940s. Co 740 continues to be cultivated in Maharashtra even now.

iii) Co 997 and Co 1148, released during 1950s, became ruling varieties in Andhara Pradesh and North India respectively. Co 1148 remained the most predominate variety in sub-tropical region for over four decades.

iv) Co 6304, a high yielder, became the most important variety in Tamil Nadu replacing Co 419.

v) Varietal evaluation for juice quality conduced across seasons helped in the indemnification of high sucrose varieties viz. Co 7204, Co 7704, CoA 7601, CoC 671, Co 8336, Co 8338 etc.

vi) Co 86249, an elite variety with resistance to red rot and high reasonability has been evolved by the Institute and notified for release in the East Coast zone, It is also serving as a source of resistance to red rot in the breeding programmes.

vii) Co 86032 Combining high yield and quality evolved by the institute and identified by the AICRP (S) has been notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties of Agricultural Crops and is occupying a major area in Tamil Nadu (90%), Karnataka, Maharashtra and Gujarat.

Improved Varieties / Hybrids :

Sr. No.	Variety	Features
1	Co-94012	14-16 duration months with 150 t/ha yield, Drought tolerant, non breaking of internode when lodge, high sugar 14.24 percentage, moderately resistant to smut and red rot.
2	Phule 265	14-16 months duration, 15-20 % higher sugar than Co86023, profuse tillering, easy for detrashing, suitable for saline soil, good ratoonability, moderately resistant smut, red rot and wilt.
3	Co-92005	Suitable for suru planting, 12-14 month duration, 128 t/ha yield capacity quality jaggery for high recovery with more market price, recommended for Western Maharashtra.
4	Phule 10001	Suitable for preseason and suru cultivation, yielding 150 t/ha (preseason), suru 133 t/ha, tolerant salinity, no pithformation, drought tolerant, excellent ratooability early maturity, moderately resistant red rot, wilt and smut.
5	COM 09057	Non lodging, suitable for mechanical harvesting, 125-130 t/ha with best jaggery quality.
6	VSI 08005	Early, good ratoonability, 15-16 % sugar, 135-145 t/ha productivity, good jaggery quality.

COWPEA

Botanical name	**:**	*Vigna unguiculata*
Family	**:**	Leguminaseae
Genus	**:**	Vigna
Species	**:**	*unguiculata (sinense)*

Chromosome No. **:** 2n = 2x = 22

Cultivated species :

Cowpeas belong to the botanical species *Vigna unguiculata* (L.) Walp. There are more than 20 synonyms for *V. Unguiculata*

Verdcourt (1970) subdivided *V. unguiculata* into five sub-species as.

Unguiculata *Cylindrica* *Sesquipedails*	Cultivated species
Dekindtiana *Mensensis*	Wild species

Marechal and Colleagues (1978) do not consider the three cultivated subspecies as distinct and grouped under one subspecies *V. unguiculata* subsp. *Unguiculata* and differentiate them by the intraspecific category 'cultigroup'.

Crossing technique :

Cowpea flowers are large and showy. Mostly flowers open between 7 and 9 am. On cloudy days the flowers may open in the afternoon. Though the flowers open late in the morning, the dehiscence of the anthers is much earlier. It may vary from 10 pm to 0.45 am. The dehiscence is influenced by environmental factors like presence of moonlight, a clear skyand a dry warm atmosphere. During dark nights the dehiscence tends to be delayed. Due to dehiscence taking place before the opening of flowers, the cowpea is self-pollinated in nature.

Since the dehiscence of anthers is much in a advance of the blooming, the emasculation needs to be carried out in mature flower buds in the preceding evening. The flower buds likely to bloom the next day (recognized by large size, the yellowish colour of the back of the standard petal) is selected for emasculation. The bud is held between the thumb and the forefinger with the keel side upper most. A needle is run along the ridge wherethe two edges of the standard unite. One side of the standards is brought down and secured in position with thumb. Same thing is done with one of the wings. After this the exposed keel is slit on the exposed side, about 1 / 16 inch from the stigma. A section of keel is also brought down and secured in position under the end of thumb. Now 10 stamens are seen. They are removed with pointed forceps. Afterwards, the disturbed parts of standard, wing and keel arebrought in original position as far as possible. To prevent drying out of the emasculated bud,a leaflet may be folded and pinned around the bud. A tissue paper can be used to cover and protect the bud.

Pollination is down next morning from a freshly opened flower. The standard and wings of male flower are removed. By slight depression of the keel, stigma covered with pollen grains protrudes out. This itself can be used as a brush for pollination. Cowpea flowers are highly sensitive and drop off easily with slight mechanical disturbance or injury. Therefore, much labour and time should be devoted to get enough crossed seed (Krishnaswamy, 1970).

Under improved techniques of Rachie *et. al.* (1975), the time taken for both emasculation and pollination has been reduced substantially and the pod set has increased from 18.6 to 26.1 per cent. Mishra *et al.* (1985) noted parental selectivity in hybridization indicating that certain lines produce more pods and seeds/ pod when used as female parents.

Breeding objectives :

1. High green pod yield (vegetable type varieties)
2. High seed yield (dry-seed type varieties)
3. High fodder yield (fodder type varieties)
4. Dual purpose (seed and vegetable type and seed and fodder)
5. Earliness
6. Appropriate plant type (erect, determinate for vegetable and seed type cultivars and spreading type for fodder type cultivars).
7. Resistance to diseases.
   a. Anthracnose (*Colletotrichum lindemuthianum)*
   b. Cercospora leaf spot (*Cersospora cruenta)*
   c. Powdery mildew (*Erysiphe polygoni)*
   d. Fusarium wilt (*Fusarium oxysporum)*
   e. Ascochyta blight (*Ascohyta phaseolorum)*
   f. Bacterial blight (*Xanthomonas campestris)*
   g. Bacterial pustules (*Xanthomonas phaseoli)*
   h. Cowpea yellow mosaic virus.
8. Resistance to insects
   a. Hairy caterpillar
   b. Leaf hoppers
   c. Aphids
   d. Thrips
   e. Bruchids
   f. Pod borer
   g. Pod sucking insects
9. Better seed quality (acceptable to consumers)
   Medium to large seed size, uniformly white / creamy / light red without black / brown scare around hilum.
10. Development of elite, high yielding 'Plant type' as a composite of following (Rachie and Rawal, 1976).
    - Tall vigorous plant
    - Deeply penetrating tap root
    - Lodging and shattering resistance
    - Low branching and or short branching
    - Narrow leaves
    - Short peduncles
    - Profusion of peduncles at nodes
    - Multiple podding of racemes
    - Long pods with many seeds
    - Weathering resistance pods and seeds
    - Medium or medium small seeds of good quality.

Achievement :

Grain purpose varieties : Pusa-152, Pusa Sawani (T-5269), CO.1, CO.2, CO.3,CO.4, K.11, K.14, RC.19
Vegetable purpose : Pusa Phalguni, Pusa Barsati, Pusa Do Fasli, Pusa Komal.
Fodder purpose varieties : Rassian Giant, T2, EC4216, K-391 and Cowpea-4.
Fodder purpose varieties at IGFRI Jhansi : Bundela Lobia-1, Bundela Lobia-2

Improved Varieties / Hybrids :

Sr. No.	Varieties	Features
1	Phule Pandhari (PCP 9708)	High yielding, short duration, Erect growth habit
2	Phule Vithai (PCP 05040)	High yielding, Indeterminate, off white, kidney shape seeds, Early, Dark purple flower colour
3	Phule Rukmini (PCP 0306-1)	High yielding, Indeterminate, Pearly white, Kidney shape seeds, Early, Erect growth habit.

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EXERCISE NO. 7

EMASCULATION AND HYBRIDIZATION TECHNIQUE IN SAFFLOWER

SAFFLOWER

(*Carthamum tinctorius*)

Family	:	Compositae
Genus	:	*Carthamum*
Species	:	*Tinctorius*
Chromosome Number	:	2n = 2x = 24

Cultivated species:

Carthamum tinctorius L (2n = 2X = 24)

Wild Species

C. palaestinus
C. oxycantha
C. lanatus
C. flavenscens

Origin:

Safflower has been grown for many centuries from Egypt in north Africa eastward to India. Safflower is believed to have two centers of origin, Ethiopia & Afghanistan.

Botany:

It is annual, erect herb having spreading type of branching. Stem is cylindrical,slightly ribbed with spiny leaves. Leaves are simple, oblong to lanceolate. Their margin is spiny and incised. Main stem terminates into flowering head called capitulum. Inflorescence is of racemose type called head or capitulum without ray florets. The whole capitulum is surrounded by number of overlapping, green, leaf like serrated (Mostly spiny) structures called bracts which collectively known as involucre. Single capitulum may contain 20 to 200 disc florets.

Disc florets are sessile, tubular and mostly bisexual. The calyx is rudimentary. Corolla is epigynous with 5 petals united (Gamopetalous) to form a tube. Upper expanded portion of corolla is called limb, which is having different colours like yellow, orange, red or white depending upon variety. It changes its colour after fertilization. Stamens are five, in syngenious condition having hairy filaments and are epipetalous. Pistil is bicarpellary and syncarpus with inferior ovary (Unilocular) having long bifid hairy stigma. After fertilization, ovule is converted into dry indehiscent, cypsela type fruit.

Flowering:

It is often cross-pollinated crop. Marginal florets open first followed by florets in central (centripetal order). It is completed within 1 to 5 days. The opening of florets takes place in the morning hours between 9 to 10 a.m. The style elongates and stigma emerges from corolla tube. At the same time, corolla opens and anthesis takes place. However, hairy portion of style is still within tube.

Breeding objectives:

1) High seed yield of oil contents
2) Wide adaptability
3) Development of early and non-spiny varieties
4) Tolerance / Resistance to
   A) Diseases
      i) Wilt
      ii) Leaf spot (particularly alternaria)
      iii) Rust
      iv) Powdery mildew
   B) Pest
      i) Gujea weevil
      ii) Aphids
      iii) *Heliothis armigera*
      iv) Hairy caterpillar
      v) Capsule
      vi) Army worm
5) Tolerance to abiotic stresses:
   i) Moisture stress (drought)
   ii) Thermo-insensitiveness i.e. for extreme temperatures
6) Development of appraisal type genotypes (to accommodate more plant population)
7) Development of stable GMS lines
8) Improvement in oil quality

Crossing Technique :

Emasculation:

Emasculation is done in previous day of anthesis in evening. The selected parents are raised in crossing block. The selected capitulum is labeled and bagged. At the time of emasculation, first involucore bracts are clipped off and disc florets are exposed. Generally one marginal whorl of florets, which is likely to open on same day, is kept on disc and other florets are nipped off. The anther tube surrounding the stigma and style is puncturedcarefully at the base and slit is opened upward. This helps to remove entire column alongwith surrounding corolla. During emasculation, some pollens may shed in the emasculated flower which are removed by rinsing the florets with jet of water or 57 per cent alchohol and then rinsed by water. The required numbers of florets are emasculated and head is properly bagged and labeled.

Mass emasculation:

Hand emasculation is time consuming and causes injury to florets as a result of which seed setting is poor. For mass emasculation, cut off free laminae of involucores bracts and cover capitulum with plastic bag and tie it till opening of flowers (in case of open capitulum, the anthers dehiscence coincides with the elongation of style so that stigmas are covered with pollen of same floret during anthesis). In this method, plastic bag prevents anthesis of flower due to increased humidity inside bag. Receptive stigma of such flowers is immediately pollinated by desired pollens just after removing polythene bag. Continue this procedure for 2 to 3 consecutive days for complete pollination. Then remove plastic bags within a week.

Pollination:

Pollen grains from desired selfed male parents are collected in petridish and dusted over the stigma of the emasculated flowers on next day morning i.e. 9 to 10 a.m. Sometimes, male capitulums (shedding pollens) are also used for pollination by hand repeat pollinationfor 1 to 3 times for effective crossing. Then the head is bagged and properly labelled after every pollination.

Achievements:

1) Pure line selection: N7, N 62-8, Bhima (81), Manjira
2) Pedigree selection after hybridization: Tarea Annegiri 1, Girna
3) Development of Commercial hybrids by using GMS: DSH 129

Improved Varieties / Hybrids :

Sr. No.	Variety	Features
1	Bhima	Moderately tolerant to aphid and fusarium wilt, oil content 29-30 %, tolerant to moisture stress.
2	Girna	Moderately tolerant to aphid and Fusarium wilt, oil content 28-30 %.
3	Phule Kusuma	Moderately tolerant to aphid, oil content 30 %
4	Phule Chandrabhaga	Moderately tolerant to aphid, oil content 29 %
5	SSF-658 (Non spiny)	Moderately tolerant to aphid and Fusarium wilt, oil content 28 %
6	Sharda (PBN-12)	High yielding, tolerant to drought Fusarium wilt and aphids.

Assignment :

1) Dissect the floral parts of given sample and mount them on black mounting paper. Draw the figures and label properly.
2) Practice hybridization technique in field and laboratory on given sample.

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EXERCISE NO. 8

HANDLING OF GERMPLASM AND SEGREGATING POPULATIONS BY DIFFERENT METHODS LIKE

PEDIGREE, BULK AND SINGLE SEED DECENT METHODS

1) PEDIGREE METHOD :

The pedigree may be defined as a description of the ancestors of an individual and it generally goes back to some distant ancestor or ancestors in the past.

In Pedigree method, a detailed record of the relationship between the selected plants and their progenies is maintained. Individual plants are selected from F_2 and subsequent generations and their progenies are tested. During the entire operation a record of all the parent offspring relationship is kept. This is known as a Pedigree record. Individual plant selection is continued till the progenies do not show segregation.

Maintenance of pedigree record:

Generally each cross is given a number, the first two digits of this number refer to the year in which the cross is made and remaining two digits denote the serial number of the cross in that year viz. e.g. 9914 denoted the cross number 14 of the year 99.

Individual plant progenies in each generation are assigned row numbers corresponding to their location in the plot. In addition each progeny in F_4 and subsequent generations is assigned the row number of the progeny in the previous generation from whichit was derived the procedure is outlined below.

Generation	Number	Description
F_3	9914-7	Progeny in the 7th row in the F_3 plot
F_4	9914-7-4	Progeny in the 4th row in F_4 plot selected from 7th row of the F_3 plot
F_5	9914-4-14	Progeny in the 14th row in F_5 plot selected from progeny in the 4th row in the F_4 plot
F_6	9914-14-3	Progeny in the 3rd row in F_6 plot selected from progeny in the 14th row in the F_5 plot.

Procedure of Pedigree method Hybridization:

The selection of parents to be used in a cross is the most important step in breeding programme during hybridization. The selected parents are crossed to produce a simple or complex cross.

F_1 generation:

F1 seeds are space planted so that each F1 plant produces the maximum F2 seed. Generally 15-30 F1 plants are raised.

F_2 generation:

In F_2 2000-10000 plants are space planted to facilitate selection. About 100-500 plants are selected and their seeds are harvested separately.

F_3 generation:

Individual plant progenies are space planted. Each progeny should have about 30 or more plants. Individual plants are selected with superior characteristics. The number of plants selected in F_3 should be preferably less than the number of F_2 selection. If number of superior progenies is small the whole cross may be rejected.

F_4 generation:

Individual plant progenies are space planted. Desirable plants are selected mainly from superior progenies. The number of plants selected in F_1 is generally much lower thanthe number of F_4 progenies. Progenies with defects and undesirable characteristics are rejected. Emphasis is given on selection of desirable plants from superior progenies.

F_5 generation:

Individual plant progenies are generally planted according to the recommended spacing. Three or more rows are grown for each progeny to facilitate comparison among progenies. Many families may have become reasonably homozygous and may be harvested in bulk. The number of progenies must be reduced to a size manageable in preliminary yield trials, which is usually of 25-100 progenies.

F_6 generation:

Individual plant progenies are planted in multi row plants and evaluated visually. Progenies are harvested in bulk, since they would have become almost homozygous. Progenies showing segregation may be eliminated. Preliminary yield trials may be planted forthese reasonably homozygous progenies which are and have enough seed. Inferior progenies are eliminated based on yield data from preliminary yield trial or visual evaluation.

F_7 generation:

Preliminary yield trial with three or more replications is conducted to identify few superior lines. Standard commercial variety must be included as a check for comparison.

F_8 to F_{10} generation:

Superior lines are tested in replicated yield trials at several locations for two to five years. The line superior to best check in yield and other characteristics would be recommended for release of new variety.

F_{11} generation:

The breeder usually multiplies its seed during its last year of trial when a strain is likely to be released as a variety. Thus in F_{11} and F_{12} seed is multiplied for distribution to the farmers.

Assignment :

Draw schematic representation of the pedigree method of handling the segregating generation

2) *BULK METHOD OF BREEDING*

Bulk Method:

In the bulk method F_2 and subsequent generations are harvested in mass or as bulks to raise the next generations. At the end of bulking period individual plants are selected and evaluated in similar manner as in the pedigree method. In this method artificial selection is not practiced.

Procedure:

Hybridization:

Parents are selected according to the objectives of the breeding programme. Simple or complex crosses are made depending on the number of parents involved.

F_1 generation:

F_1 is space planted and harvested in bulk. The number of F_1 plants should be as large as possible usually more than 20 plants should be grown.

F_2 to F_6 generation:

F_2 to F_6 are planted at commercial seed rates and spacing. These generations are harvested in bulk. Artificial selection is not done. The population size should be as larges as possible in each generation, i.e. 30 to 50 thousand plants.

F_7 generation:

About 30 to 50 thousand plants are space planted and about 1000 to 5000 plants are selected with superior phenotype and their seed is harvested separately. Selection is based on phenotype of plants, grain characteristics, disease resistance etc.

F_8 generation:

Individual plant progenies are grown in single or multi row plots. Most of the progenies would be reasonably homozygous and are harvested in bulk. Weak and inferior progenies are rejected on the basis of visual evaluation. Only 100 to 300 plant progenies are selected with desirable characteristics.

Preliminary yield trial is conducted. Standard commercial varieties are used as checks. The yield is used as basis of selection of superior progenies. Quality test may be conducted.

F_{10} to F_{12} generation:

Replicated yield trials are conducted over several locations using standard commercial varieties as checks. The lines are evaluated for important characteristics in addition to yield i.e. disease resistance, quality etc. If a line is superior to the standard varieties in yield trials, it would be released as a new variety.

F_{13} generation:

The seed of the released variety is increased for distribution to the cultivators.

3) SINGLE SEEED DESCENT METHOD (Modification of bulk method)

In this method a single seed from each of the one to thousand F_2 Plants is bulked to raise the F_3 generation. Similarly, in F_3 and subsequent generations one random seed is taken from every plant present in the population and planted in bulk to raise the next generation. This procedure is followed till F_5 or F_6 when the plants would have become nearly homozygous. In F_5 or F_6 a large number of individual plants are selected and individual plant progenies and the number of progenies is sufficiently reduced to permit replicated trial in the next generation. Individual plants may be selected only from outstanding families showing segregation. Thus, preliminary yield trials and quality tests being conducted in F_7 or F_8 and co-ordinated yield trials in F_8 or F_9 generations.

The objective of the single seed descent method is to advance the generation of crosses rapidly. At the end of the scheme a random sample of homozygous or merely homozygous genotypes lines is obtained. F_2 and subsequent generations are grown at very high plant densities as vigour of plant is not important. In each year 2-3 generations may be raised using off season nurseries and green house facilities.

The important features of single seed descent method are :

Lack of selection, natural or artificial till F_5 or F_6 when the population is reasonably homozygous.

Raising of F_5 and later generations from a bulk of one seed from each F_2 and subsequent generations.

Assignment :

Draw the diagrams of scheme for Bulk method of Breeding & single seed descent method

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EXERCISE NO. 9

STUDY OF FIELD TECHNIQUES FOR SEED PRODUCTION AND HYBID SEED PRODUCTION IN *RABI* CROPS

Selection of Appropriate field :

Selection of appropriate field is the key to success of a seed production programme. The field should be such that it enables the seed crop to express all the passport traits uniformly in all the individual plants of the crop. Passport traits are those traits that form the basis of unambiguous identification of the variety concerned. This is possible when the field is ideal for the crop and does not exhibit heterogeneity with respect to various gradients, such as, Fusarium wilt of legumes, the filed soil must be free from these pathogens.The field for seed production should not be deficient in mineral nutrients or suffer from mineral toxicity as these may influence seed yield and quality. For example, deficiency of boron is known to cause sterility in cereals and 'hallow heart' abnormality in pea seed. The field should be also be free from weed seeds; this would not only facilitate crop cultivation, but would also ensure seed purity. In general the seed crop should be planted in a clean,fertile and problem free field in an area for which the variety is recommended.

Sowing a class of improved seed :

After the land is suitably prepared, a class of improved seed (nucleus, breeder, foundation) is sown following the recommended method. As a rule, the class of seed sown is one time higher than the class of seed targeted for production, except in extraordinarysituations when a stage I seed can be used to produce the stage II seed of the same class. The row-to-row spacing is kept such that there is enough space for movement in the field for rouging, inspection, etc. In case of breeder seed plots, where seed drills are used one row space is left blank between two runs of the seed drill.

Maintenance of recommended isolation :

Isolation literally means keeping the seed production plots aloof from other fields of the same crop. Seed production plots should be located at such a distance that there is no risk of contamination by pollen from the neighbouring fields; the contamination in a seed plot by volunteer plants; of mixture with seed transported by brides or water; of contamination through cross-fertilization by wind boren pollen. A volunteer plant is a plant of the same cropthat has arisen from seed dropped in the field from the crop grown during the previous crop season. Isolation is not only important for maintaining genetic purity, but is also necessary for controlling seed-borne disease, such as loose smut of wheat and barley (caused by *Ustilago tritici* and *U. nuda, respectively*) and dwarf bunt of wheat (caused by *Tilletia species*).

Isolation between seed plots can be effected by distance (*spatial isolation*) or time (temporal isolation). The distance used for isolation largely depend on the distance that can be travelled by the pollen from the contaminating source to cause a significant level of contamination. Thus it is decided by the mode of pollination and sometimes on the velocity and the direction of prevailing wind. Adoption of distance isolation is relatively easy in self-pollinated crops, where isolation distance is few meters. In cross-pollinated crop the isolation distances are generally in the range of few hundred meters (Table) therefore, it is not easy to practice space isolation is these crops. The isolation distance also depends on the type of seed class to be protected by isolation as well as the nature of the material from which isolation is sought. For example, the isolation distance for nucleus and breeder seeds are much more stringent than for the seeds of later generations. *viz.,* foundation and certified seeds.

Minimum seed certification standards of certified seed of some crops

Crop	Seed	Isolation (m)	Purity (%)	Germination (%)	Moisture (%)	Weeds / kg
Wheat	Pure lines	3	98	85	12	5
	Hybrids	100	98	85	12	5
Rabi Sorghum	OPVs	100	98	75	12	10
	Hybrids	200	98	75	12	10
Pea	Pure lines	5	98	75	9	0
Rapeseed / mustard	Pure lines / OPVs	50	97	85	8	10
Sunflower	OPVs	200	98	70	9	0
	Hybrids	400	98	70	9	0
Potato	Potato seed	50	98	80	8	10

When space isolation is not possible, time isolation can be used. In case of time isolation, different sowing is done so that an thesis in a seed field does not coincide with that in the other fields. Obviously, the flexibility in time isolation is determined by the length of the crop season. In almost all crops, late sowings are not admissible due to yield reductions and greater chance of occurrence of biotic and abiotic stresses.

When both time and space isolations are not possible, mechanical barriers may be used. Mechanical barrier is generally achieved by growing thick stands of fast growing crops having greater height e.g., *Sesbania* in the case of hybrid rice. Occasionally, use of walls or artificial barriers like cloth or plastic sheets may also be used.

Before the emergence of seed technology, what was considered to be adequate isolation was solely based on practical experience. With expansion in knowledge,experimental evidence was accepted as the basis for such decisions. For example, in the case of wheat, the earlier recommendation for isolation distance was three meters. But experiments suggested that in case of loose smut infestation, the appropriate isolation distance should be 150 meters. In general, the greater the isolation distance, the smaller is the possibility of contamination. However, it is difficult to achieve complete isolation for seed plots of a given variety in the crop production regions of a crop. Therefore, seed production plots are so isolated as to keep level of contamination below the prescribed minimum for the concerned seed class.

Appropriate Male : Female Ratio

Male : female ratio is relevant only in the case of hybrid varieties where the F_1 seed (that is to be used for commercial crop production) is the result of cross- pollination between two parents. In such cases, only the female parent (which is mostly genetically emasculated) bears the hybrid seed; it is, therefore, harvested separately. Further, yields of hybrid seeds are lower than from fields where the whole populations are harvested, e.g., in the case of pure line, synthetic, etc., varieties; this is one of the reasons for the higher cost of hybrid seeds. In order to minimize the seed cost male : female ratio is generally kept in favour of the female parent. The male : female ratio is decided on the basis of experimental investigations, and may by 1 : 1, 1 : 2, 1 : 3, 2 : 4

Commonly used male : female ratio in the hybrid seed production of some crops.

Crop	***Male : female ratio***
Maize	1 : 2, 2 : 4, 2 : 6
Rice	1 : 4, 2 : 10, 2 : 8
Cotton	1 : 2
Pearl millet*	2 : 4, 2 : 10, 2 : 16
Sorghum	2 : 4

* varies from hybrid to hybrid

Following recommended agronomy

Seed production must be done following the recommended package of agronomy for the concerned crops. Beginning from sowing through fertilizer application, irrigation, weed and pest control and till harvest, the field crop condition must be maintained around the optimum. This would not only enable a seed grower to harvest the maximum possible yields, but would also reduce the environmental effects and genotype x environment interactions that create undesirable variability in plant populations. A uniform application of package of practices helps in the detection of off-types facilitating their rouging, and helps in satisfying field inspection requirements. An uneven or variable plant population cannot be critically inspected for genetic purity, hence is considered unfit for seed production.

Field inspection

Field inspection refers to the scrutiny of seed production plots by a team of qualified persons. The primary objective of field inspection is to ensure that the seed production pertains to the designated variety and that it has not been contaminated genetically physically beyond certain specified maximum limits. Field inspections also ensure that the steps necessary to minimize genetic and physical contamination have been taken properly and in time to make them effective. The aims of field inspections are fulfilled by verifying the following about the seed crop.

1. It has been raised from such seed whose source is approved.
2. It has been grown in a field area, which satisfies the prescribed land requirements.
3. In case of hybrids, the planting is as per the prescribed male : female ratio.
4. The prescribed isolation or border rows (in case of hybrids) have been provided.
5. Seed crop has been properly rouged to remove off-types, objectionable weeds and inseparable other crop plants so as to conform to the maximum limits of standards prescribed for these factors.
6. The crop is true to the varietal characteristics descriptive of the concerned variety.
7. The seed crop is harvested properly to avoid mechanical admixture.
8. The disease incidence, particularly of specified disease, is below the maximum permissible limits.
9. The crop complies with such other special requirements that may be specified for the crop concerned.

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EXERCISE NO. 10

ESTIMATION OF HETEROSIS, INBREEDING DEPRESSION AND HERITABILITY

Introduction :

Heterosis refers to the superiority of F_1 hybrid in one or more characters over its parents. In other words, heterosis refers to increase in fitness and yield over parental values. Heterosis is also called as hybrid vigour. There are three possible genetic causes of heterosis, *viz*. dominance, over dominance & epistasis. Out of these causes, dominance is widelyaccepted. In crop plants, there are three main ways of fixing heterosis, *viz*. asexual reproduction, apomixis and polyploidy.

Heterosis is estimated in four ways, viz. (1) over mid parent, (2) over better parent, (3) over commecial cultivar, and (4) over commercial hybrid(check). These are called as average heterosis, heterobeltiosis, useful heterosis (economic heterosis) and standard heterosis, respectively; Standard heterosis is estimated in those crops where hybrids are already available for comparison. Various types of heterosis are estimated as follows:

1. Mid-parent heterosis $= \dfrac{F_1 - MP}{MP} 100$

2. Heterobeltiosis $= \dfrac{F_1 - BP}{BP} 100$

3. Useful or economic heterosis $= \dfrac{F_1 - CC}{CC} 100$

4. Standard heterosis $= \dfrac{F_1 - SH}{SH} 100$

Where,
- F_1 = Mean value of a particular cross
- Mp = Mean of two parents involved in the cross
- BP = Mean Value of better parent of a cross
- CC = Mean value of a commercial cultivar
- SH = Mean value of Standard (check) hybrid.

In plant breeding, useful and standard heterosis has direct practical significance. Positive heterosis denotes the excelled performance of hybrid suggesting increased value of particular character eg. + ve heterosis for grain yield, fruits/tree, branches /tree etc.indicates high yielding ability of hybrid over parents. Where as, Negative heterosis shows reduced performance of hybrid as compared to parents. Such type of – ve heterosis is useful where we want the hybrid should have reduced performance for particular character viz. dwarfness, earliness in flowering /maturity etc.

Inbreeding depression: - Inbreeding depression refers to decrease in fitness and vigour in F_2 due to inbreeding (mating plants with similar genetic constitution) Inbreeding depression is estimated when both F_1 and F_2 populations of the same cross are grownsimultaneously. It is estimated with the help of following formula.

$$\text{Inbreeding depression} = \frac{F_1 - F_2}{F_1} \times 100$$

Where F_1 = Mean value of F_1 Cross

F_2 = Mean value of above F_1 cross in F_2 generation

Solved Problems

Problem –1

In rice, grain yields (q/ha) of parents (P1 and P2), their F1 and F2 progenies are given below:

Parent 1	Parent 2	F_1 Hybrid	F_2 Progeny
18.94	**22.69**	**29.38**	**15.18**

Calculate average heterosis, heterobeltiosis and inbreeding depression.

Solution:

$$\text{Mid-Parent heterosis} = \frac{F_1 - MP}{MP} \times 100$$

Here, Value of F_1 = 29.38

$$\text{Mean of Parents (MP)} = \frac{18.94 + 22.69}{2}$$

= 20.81

$$= \frac{29.38 - 20.81}{20.81} \times 100$$

Heterosis = 41.12%

$$\text{Heterobeltiosis} = \frac{F_1 - BP}{BP} \times 100$$

Better Parent Value = 22.69

$$= \frac{29.38 - 22.69}{22.69} \times 100$$

Heterobeltiosis = 29.48 %

$$\text{Inbreeding depression} = \frac{F_1 - F_2}{F_1} \times 100$$

$$= \frac{29.38 - 15.18}{29.38}$$

= 48.33 %

Answer :

Average heterosis	=	41.12%
Heterobeltiosis	=	29.48%
Inbreeding depression	=	48.33%

Problem for exercise:

Problem- 1

In Tur, yield data per plant (g) for parents (P1 and P2), their F_1 and F_2 progeny, and for a commercial cultivar and hybrid are given below.

P1	P2	F_1	F_2	Check Cultlivar	Check hybrid
50	40	90	35	70	80

Calculate useful heterosis, standard heterosis and inbreeding depression.

Problem -2

2. (a) Define heterosis.
   (b) Estimate useful Heterosis and standard Heterosis from the following data of yield per plant (g) in Nagli.

Parent 1	Parent 2	F_1	F_2	Commercial Check	Commercial Hybrid
45.5	56.2	110.4	50.6	65.0	85.5

Problem 3 :

What will be the yield of F_2, when Inbreeding Depression is 39.77 per cent and the grain yield of F_1 is 24.68 g/plant?

Problem 4:

Work out the yield of F_1, when heterobeltiosis is 67.80 per cent and grain yield of better parent is 52.45 g/plant

Problem 5:

Explain the genetic reason for reduced yield in F_2 generation as compared to F_1.

ESTIMATION OF HERITABILITY

Introduction:

Heritability is an index of the transmission of characters from parents to their offspring. Heritability is of two types, viz. broad sense heritability and narrow sense heritability. Broad sense heritability is the percentage ratio of genotypic variance to the phenotypic variance, whereas narrow sense heritability is the ratio of additive variance to the phenotypic variance.

Broad Sense Heritability

The broad sense heritability, from different materials, is estimated in different ways. From replicated data of several genotypes, heritability is calculated as follows:

$$\text{Heritability (bs)} = \frac{V_G}{V_p} 100$$

Where, V_G = genotypic variance, V_p = Phenotypic variance

From generation mean analysis, the heritability is worked out with the help of following formula

$$\text{Heritability (bs)} = \frac{VF_2 - VF_1}{VF_2} 100$$

Where, VF_1 = Variance of F_1 progeny
VF_2 = Variance of F_2 progeny

Narrow Sense Heritability

It is also calculated in different ways from different breeding materials and biometrical techniques.

From Diallel Analysis :

The following formula is used for calculation of heritability (ns).

$$\text{Heritability (ns)} = \frac{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{2}H_2 - \frac{1}{2}F}{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{4}H_2 - \frac{1}{2}F + E} \times 100$$

Where, D = Variance due to additive effect of genes
H_1 = Variance due to dominance effect of genes

$H2 = H1\,[1 - (u - v)^2]$, where u and v are proportion of positive and negative genes in the parents.

F = the mean of Fr over the array, where Fr is the covariance of additive and dominant effects in a single array.

E = Expected environmental component of variance

Verhalen and Murray (1969) proposed the following formula for calculation of heritability from F_2 generation of a diallel cross.

$$\text{Heritability (ns)} = \frac{\frac{1}{4}D}{\frac{1}{4}D + \frac{1}{16}H_1 - \frac{1}{8}F + E} \times 100$$

From Partial Diallel Analysis

The heritability is calculated by the following formula:

$$\text{Heritability (ns)} = \frac{2V\,gca}{2V\,gca + V\,sca + V_E} \times 100$$

Where, Vgca = Variance due to general combining ability
Vsca = Variance due to specific combining ability
VE = Error variance.

From Line X Tester Analysis

The heritability is calculated by the following formula:

$$\text{Heritability (ns)} = \frac{V\,gca}{V\,gca + V\,sca + V_E} \times 100$$

From Generation Means

Mather (1949) and Warner (1952) have suggested separate method of calculating heritability from generation means as given below:

$$\text{Heritability (ns) as per Mather (1949)} = \frac{D}{D + H + E} \times 100$$

Where, D = Additive variance
H = Dominance variance, and
E = Error variance

$$\text{Heritability (ns) as per warner (1952)} = \frac{\frac{1}{2}D}{VF_2} \times 100$$

Where VF_2 = Variance of F_2 generation

Solved Problems

Problem –1

In Pigeonpea, 33 genotype were evaluated for grain yield in RBD with three replication and following mean square values were obtained for genotypes and error:

MSS treatments (genotypes) = 16.47, MSS error = 2.83, X = 11.68

Find out the value of heritability

Solution :

First we have to calculate genotypic and phenotypic variances as follows:

$$\text{Genotypic Variance (VG)} = \frac{\text{MSS tr} - \text{MSS e}}{\text{Replication}}$$

$$= \frac{16.47 - 2.83}{3}$$

$$= 4.547$$

$$\text{Phenotypic Variance } (V_P) = V_G + V_E$$
$$= 4.547 + 2.830$$
$$= 7.377$$

$$\text{Heritability} = \frac{V_G}{V_P} \times 100$$

$$\text{Heritability} = \frac{4.547}{7.377} \times 100$$

$$= 61.64\%$$

Heritability (bs) = 61.64%

Problem – 2

In a 8 x 8 diallel cross of cotton, following parameters were obtained for fibre length

D	H_1	H_2	F	E
6.47	3.39	2.86	2.00	0.61

Calculate heritability in narrow sense.

Solution :

From diallel analysis, heritability is estimated with the help of following formula:

$$\text{Heritability (ns)} = \frac{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{2}H_2 - \frac{1}{2}F}{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{4}H_2 - \frac{1}{2}F + E} \times 100$$

$$= \frac{\frac{6.47}{2} + \frac{3.39}{2} - \frac{2.86}{2} - \frac{2.00}{2}}{\frac{6.47}{2} + \frac{3.39}{2} - \frac{2.86}{4} - \frac{2.00}{2} + 0.61} \times 100$$

$$= \frac{4.93 - 2.43}{4.93 - 1.715 + 0.61}$$

$$= \frac{2.500}{3.825} = 65.36\%$$

Problem –3

Genotypic and phenotypic variances and covariances of two characters (x and y) are given below:

GV x = 3.252, PVx = 5.044, G Cov xy = 1.657
GV x = 4.728, PVx = 5.520, P Cov xy = 2.142

Calculate heritability of X and Y

Solution:

$$\text{Heritability of X} = \frac{GV_X}{PV_X} \times 100$$

$$= \frac{3.252}{5.044} \times 100$$

$$= 64.47\%$$

$$\text{Heritability of Y} = \frac{GV_y}{PV_y} \times 100$$

$$= \frac{4.720}{5.520} \times 100$$

$$= 85.51\%$$

Problem – 4

Following estimates were obtained from generation mean analysis

$VF_1 = 0.051$, $VF_2 = 0.218$, $D = 0.084$
Calculate heritability in broad sense and narrow sense.

Solution:

$$\text{Heritability (bs)} = \frac{VF_2 - VF_1}{VF_2} \times 100$$

$$= \frac{0.218 - 0.051}{0.218} \times 100$$

$$= \frac{0.167}{0.218} \times 100$$

$$= 76.60\%$$

$$\text{Heritability (ns)} = \frac{\frac{1}{2} D}{VF_2} \times 100$$

$$= \frac{\frac{0.084}{2}}{0.218} \times 100$$

$$= \frac{0.042}{0.218} \times 100$$

$$= 19.26\%$$

Problem – 5

Calculate broad sense heritability from the following estimates obtained from generation mean analysis .

D = 0.842, H = 1.465, E = 0.072

Solution:

$$\text{Heritability} = \frac{D}{D + H + E} \times 100$$

$$= \frac{0.842}{0.842 + 1.465 + 0.072} \times 100$$

$$= \frac{0.842}{2.379}$$

$$= 35.39\%$$

Problem – 6

The following estimates were obtained from a diallel analysis

$V_{gca} = 381.26$, $V_{sca} = 147.43$, $V_e = 3.65$

Calculate heritability in narrow sense.

Solution:

The following formula is used for calculation of heritability (ns) from above estimates obtained either from diallel cross or partial diallel cross.

$$\text{Heritability} = \frac{2\,V\,gca}{2\,V\,gca + V\,sca + V\,e} \times 100$$

$$= \frac{2\,(381.26)}{2\,(381.26) + 147.43 + 3.65} \times 100$$

$$= \frac{762.52}{762.52 + 147.43 + 3.65} \times 100$$

$$= \frac{762.52}{913.6} \times 100$$

$$= 83.46\%$$

Problem – 7

In Rice, following estimates were obtained for Line X Tester analysis.

V *gca* = 34.15, V *sca* = 12.27, V *e* = 0.32

Calculate heritability in narrow sense.

Solution:

The following formula is used for estimation of heritability from above estimates obtained from line X tester analysis.

$$\text{Heritability} = \frac{V\,gca}{V\,gca + V\,sca + V\,e} \times 100$$

$$= \frac{34.15}{34.15 + 12.27 + 0.32} \times 100$$

$$= \frac{34.15}{46.74}$$

$$= 73.06\%$$

Problem –8

In a study, following estimates of genotypic, environmental, dominance and epistatic variances were obtained for a character.

Variance Estimates	V_G	V_E	V_D	V_I	VP
	160	240	40	15	400

Calculate heritability in narrow sense.

Solution

The following relationship is observed in variances

$V_P = V_G + V_E$

$V_G = V_A + V_D + V_I$

$VG = 160,\ V_E = 240,\ V_D = 40,\ V_I = 15$

$VP = 160 + 240 + 400$

$160 = V_A + 40 + 15$

or $V_A = 160 - 55$

$= 105$

$$\text{In narrow sense heritability} = \frac{V_A}{V_P} \times 100$$

$$= \frac{105}{400} \times 100$$

$$= 26.25$$

Ans. Heritability (ns) = 26.25%

Problem For Exercise :

1. (a) Define broad sense heritability.
   (b) Analysis of variance was performed with 33 genotype of Tur tested in Randomized Block Design with 3 replications and following values of mean squares were obtained for test weight.
   MSS (genotype) = 16.55, MSS (error) = 2.40, X = 41.70
   Calculate heritability and genetic advance.
2. (a) Define narrow sense heritability.
   (b) In cotton, following, parameter were obtained from a 8 x 8 diallel cross for lint index

D	H_1	H_2	F	E
0.41	0.39	0.23	0.21	0.09

   Find out heritability in narrow sense.
3. (a) Define heritability.
   (b) Calculate heritability from the following statistics.
   VG x = 7.12, VP x = 8.42 VG y = 0.130, VP y = 0.150
4. (a) Define heritability
   (b) From generation mean analysis, following values of D, H and E were obtained. Calculate heritability in narrow sense.
   D = 0.263, H = 0.481, E = 0.024
5. (a) Define generation mean analysis
   (b) From generation mean analysis, the following estimates were obtained
   D = 0.036, VF_1 = 0.074, VF_2 = 0.154
   Calculate heritability in broad sense and also in narrow sense
6. (a) Define Partial diallel
   (b) Following estimates were obtained from partial diallel analysis
   V_{gca} = 1.46, V_{sca} = 1.18, V_e = 0.14
   Calculate heritability in narrow sense.
7. (a) Define Line x tester cross
   (b) In blackgram, following estimates were obtained from Line X tester analysis. V_{gca} = 16.72, V_{sca} = 42.16, V_e = 1.42
   Calculate heritability in narrow sense.
8. (a) Define additive variance
   (b) Calculate heritability from the following estimates of genotypic, environmental, dominance and epistatic variances for ear length in corn.

Variance	VG	VE	VD	VI
Estimates	210	190	60	25

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EXERCISE NO. 11 LAYOUT OF FIELD EXPERIMENTS

Techniques in conducting field trials:

The proper conduct of field trials is of major interest to the plant breeder. In his search for a new variety the breeder usually finds it necessary to grow a very large assortment of experimental strains. Most of the strains will be inferior in some respects. If their undesirable features can be recognized, they may immediately be eliminated from further consideration. In ordinary practice, the procedure is first to grow large numbers of new strains, which have a limited seed supply, in small observation plots where the breeder evaluates their maturity, height, lodging, disease resistance, and other characteristics including over-all vigour. From these visual observations the breeder selects what appears to him to be the superior strains. The superior strains are then grown in replicated field trials to determine more accurately their potential performance, including yield, in comparison with standard commercial varieties. Since replicated field trials are more expensive to conduct, fewer strains are testedin them in comparison with the very large number of strains that may be grown in the preliminary observation nurseries. Even when outstanding experimental strains are encountered, their yield superiority over the best commercial varieties will generally be small. This need to measure small yield differences accurately is most important in advanced trials in which only elite strains are being tested. By this time the breeder might have already eliminated the strains those were found grossly inferior by the observation in nurseries and in preliminary yield trials.

Nursery vs. Field Plots.

Nursery plots are small. Single or multiple row plots in which varieties of field crops are grown for observation or yield trials. The size of the plots will vary with the crop, the amount of seed available, and the nature of the observations which the breeder expects to make. The nursery plot is used when (a) the seed supply of the strain is limited, and when (b) a large number of strains are to be tested.

Field plots are of such size and shape that they may be planted and cultivated with standard farm implements. Usually, field plots vary from 1/10 to 1/100 acre in size. Field plots more closely related actual field conditions than do nursery plots. They are valuable as observation plots, because their size makes it easy for the breeder to make visual observations of the performance of a variety. They are useful for making preliminary seed increase. Field plots require more seed and are more expensive for testing a given number of varieties than are nursery plots. In general, field plots are used only for testing a few elite experimental strains and standard varieties, after the superiority of a strain or variety has been demonstrated in nursery plots.

Principles in Plot Technique:

The purpose of conducting variety performance trials is to measure comparativeyields, maturity, height, lodging, disease resistance, and other characteristics of varieties and experimental strains of particular crop.

In order to have accurate results, the experimenter must follow careful and proven procedures that are uniformly carried out with all the strains included in the test and he must eliminate personal bias in recording notes and in interpreting the data.

Soil variability:

The variation in the soil is one of the important sources of error in field plot trials. Even in small plots the soil may differ in fertility, drainage and texture and plants of similar variety growing within a few feet of each other may perform differently. Previous soil treatments often leave residual effects that affect the growth of the succeeding crop.

Therefore, experimental site used for performance trials should be selected carefully considering topography, drainage, fertility, previous treatments and uniformity. It is often helpful to observe the uniformity of the preceding crop before selecting the exact area to be used for a performance trial. Generally, plots that are long and narrow will most effectively sample the soil variations, if the long dimension of the plot is in the direction of the gradient in soil fertility.

B) Competition and Border Effect:

Plants of different varieties in adjacent rows compete for the soil moisture and plant nutrients. A vigorously growing variety may adversely affect the performance of a variety in an adjacent row, especially if moisture or nutrients are limited. Tall growing varieties may shade shorter varieties in adjacent rows. The performance of varieties growing in adjacent rows may also be affected by differences in maturity, lodging or type of growth. To reduce the error resulting from competition between varieties, it is a common practice to plant nursery yield tests in three- row plots and harvest only the center row, or to plant four-row plots and harvest two center rows. To eliminate border effect, it is common practice to plant along sides of the plots several rows of standard variety which are discarded before harvest. Ends of the plots are also discarded before harvest.

Replication:

The recorded yield of a plot is always subject to some error in the conduct of yield trials. Depending upon the extent and the direction of the error, true yield of an individual plot will be either larger or smaller than the recorded yield. If the error is due to chance, it may be expected that the yield of different individual plots of the variety will fluctuate around the true yield. If the yields of several plots of the variety are averaged, the chance fluctuations will be less. For this reason, the mean yield of several plots of a variety is a better estimate of the true yielding ability of a variety than the yield of a single plot. The number of times a treatment (variety) is repeated in an experiment is commonly referred to asthe number of replications. This may range from design of the experiment, the accuracy desired in the yield data, and the amount of land and seed available. In most standard yield trials, either four or five replications are planted. Replication is necessary to sample effectively the variations in soil fertility. Replication provides the means for experiment. Adequate number of replications are used for performance trials that are harvested for yields.

Location and Seasonal Variation:

Varieties perform differently in different locations and in different seasons. On fertile lands with adequate soil moisture throughout the growing season, early varieties may be out yielded by the late varieties. In another situation, where moisture is a limiting factor at the end of the season, the early varieties may yield more than late varieties. Or consider the yieldof two adapted varieties of wheat, one resistant to black rust and the other susceptible. In a season without rust damage, the susceptible variety might out yield resistant but in a severe rust damage, resistant variety would out yield than susceptible.

.Assignment :

Give Diagrammatic representation of field plot designs.

MAINTENCE OF RECORDS & REGISTERS

Keeping accurate records / registers:

Plant breeder does evaluate thousands of strains to select for desirable characters, to be tasted during another season. Detailed records of such selections are made in various records. Unless these records are complete and accurate, the breeder will be unable toevaluate the performance of the breeding materials..

Every breeder has his own system of record-keeping. However, an efficient system of record-keeping should possess the following requisites:

1. **Completeness**: The breeder should be able to identify from his record the parentage of particular strains as well as their current performance. The notes recorded on performance will vary with the crop, but generally they should include such observations as height, lodging, relative earliness of maturity, reaction to prevailing diseases or pests, and over-all vigour. If a yield test, they will also include yield and quality evaluation of the grain, fibre, or forage. Special identifying characteristics may be desirable to note, even though theyhave little or no relation to performance.

2. **Accuracy:** Most important requirement of any experiment is accuracy in observations and the manner in which they are recorded. Accuracy in making observation comes with experience and careful attention to details. Notes recorded in a clear, legible manner will reduce the number of errors. Field notes are usually taken with a pencil of moderate hardness to prevent smearing and should be made in hard bound notebooks.

3. **Simplicity:** Any system of record-keeping should be simple in its operation. Otherwise the breeder will bog down in the detail of its upkeep and will fail to maintain up-date records. The record system should be sufficiently simple for the breeder or any of his helpers to be able to maintain it and to interpret the notes recorded.

Precautions to breeder in taking notes :

1. Every row or plot in the nursery should be easily and accurately identified by a row or plot number. This is easily done by dividing blocks into ranges and by following a uniform system of numbering ranges and rows (or plots). i.e., all plots within a block may benumbered by starting from a certain corner, say the northwest, and proceeding from left to right.
2. Adequate plot markers should be placed on a plot quickly and easily. Rows may be marked at regular intervals, and if groups of related materials are planted together, a separate marker may be set to identify the first row of each group.
3. Crosses and advanced strains may be given permanent accession numbers. Each cross may be identified by a separate number, and selections from these crosses may be numbered so as to identify the year or generation selected. All strains advanced into yield should receive permanent accession numbers.
4. Permanent records may be recorded on standard notebook forms that are easily summarized. For yield tests, printed field notebook forms may be used with appropriate column headings, according to the date to be recorded.

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EXERCISE NO. 12

STUDY OF QUALITY CHARATERS, STUDY OF DONAR PARENTS FOR DIFFERENT CHARACTERS

QUALITY BREEDING IN SOME IMPORTANT CROPS

Quality refers to the suitability or fitness of an economic plant product in relation to its end use. The concept of quality breeding is complex and varies with the crop and its use. There is an urgent need to incorporate quality evaluation in breeding programmes.

Quality includes several features of a product. For example, in wheat grain quality consists of colour, shape, size and luster of grain; milling and baking qualities; and nutritional quality which includes protein content. Thus the quality is of three main types, viz. (1) Market quality (2) Industrial quality, and (3) nutritional quality.

1. Market quality :

The market quality refers to fitness of a product for marketing. It includes uniformity in shape, size, colour and texture in food and vegetable crops.

2. Industrial quality :

The industrial quality includes suitability for baking in wheat, malting in barley, crushing in sugarcane, canning in fruit crops, etc.

3. Nutritional quality :

The nutritional quality refers to the suitability or fitness of a plant product for human and animal consumption.

Quality traits in some important crops :

The genetic improvement of crop plants in relation to various quality attributes is referred to as quality breeding.

Quality traits or characters differ from species to species depending upon the plant part used as economic product. The important quality traits of different crop plants are briefly presented below :

1) Wheat : In wheat, white or amber grain colour medium to bold size, and lustrousappearance are important features for good market quality. High lysine content and good baking quality are essential for use in biscuit and bread manufacturing.

2) Barley : In malting barley, low protein content and high extract of soluble oligosaccharides after malting are desirable characters. Low protein produces less haze in beer and high oligosaccharides are suitable for fermentation.

3) Pulses : In pulse crops attractive shape, size and colour of grains, high protein contents; high methionine and tryptophan, and less flatulence are desirable characters.

4) Oilseeds : In oilseed crops, attractive shape, size and colour of seeds, high oil content free from antinutritional factors and more proportion of unsaturated fatty acids are theimportant quality characters.

5) Sugarcane : Moderate hardness, long internodes, optimum (low) fibre for milling, sucrose ratio, high sucrose content and good quality of juice are desirable traits in sugarcane.

6) Forage crops : Greater nutritive value, more palatability and freedom from toxic substances are the desirable characters in forage crops.

Thus, quality differs according to economic use of plant product. There are four major goals of breeding for improved nutritional quality. These are breeding for (1) high content and quality of protein, (2) high content and quality of oil, (3) high vitamin contents and (4) low toxic substances which are harmful for human health.

Breeding methods :

Breeding methods used for improvement of quality do not differ from methods used for any other character. Breeding methods used for improvement of quality traits include backcross, pedigree method, single seed descent, recurrent selection, progeny selection and mutation breeding.

Quality Assessment:

The system for quality assessment in plant breeding programs should be quick, cheap and economical of material since plant breeder thousands of stocks each year, having limited time and limited material for testing.

1) Organoleptic Characters:

Effected to characterize flavours chemically have failed. So the breeder, aided by a taste panel looks at, smells and taste his fruits and vegetables and pulses and takes decisions. If material to be examined after processing, he will take care to standardize the preparation procedure as closely as possible.

2) Chemical Quality Assessment:

The emphasis of assessment of chemical quality is given on small scale and speed viz. In sugar plants sucrose content an optical measurement of total dissolved solids in juice (Brix) is sufficiently highly correlated with sucrose to be good enough for which refractometer is used while in barley, low protein content (in beer) and high extract of soluble (fermentable) oligosaccharides after malting are desired. Hence, nitrogen content and soluble carbohydrates after micro malting of few grains in vitro is enough than protein per se.

3) Mechanical assessment of quality:

The measuring of characters of fibers will predict the industrial performance of the product. The breeder use visual methods to some extent in cotton but relies mostly on various mechanical devices for measuring length, strength and fineness. He also considers maturity is a condition as well as a quality factor. Breeder should aim at a determined market standard.

1. Biological Assessment of Characters :

The quality objective of forage fodder breeding programmes are biological in character and would be met by testing animal growth. The chemical proxies for nutritional value are sought. Thus soluble carbohydrate content, fiber content and digestibility of fodder / forage crops is estimated **by chemical / physical methods.**

The industrial scale testing is generally essential before a new variety is marketed so wheat's are milled, barely malted, potatoes crisped, cotton spun, apples stored, strawberries Jammed and bananas shipped before final decisions are taken. However, instead of testing fodders by animal growth, in practice decision is taken on analysis basis.

SOURCE OF DONAR PARENTS FOR DIFFERENT CHARACTERS

Sr. No.	Name of Crop	Name of cultivated and wild species	Salient features
1)	WHEAT	**A) Cultivated species**	
		i) *Bread Wheat Triticum aestivum L. Thell*	
		ii) *Durum wheat Triticum turgidum var. durum*	
		iii) *Dicoccum/Emmer wheat Triticum turgidum var. dicoccum*	
		B) Wild species	
		i) *T. monococum*	Stem rust and Herbicide resistance
		ii) *A. curviflarum*	Resistance to leaf spot disease
		iii) *A. Squarrosa*	Resistance to Kermel Blunt. Higher tiller / plant grains / spike and bolder sedds.
		iv) *A. speltoides*	Heat tolerance
		v) *A. ovata*	High Protein content and kernel weight
		vi) *T. dicoccides*	Stripe rust resistance, powdry mildew resistance.
		vii) *T. timopheevii*	Cytoplasm shows stable male sterility after interaction withnuclear factor of T. aestivum, Improment in grain character.
2)	SUGARCANE	**A) Cultivated species** *i) S. Barberi* *ii) S. Sinese* *iii) S. Officinarum*	It is tall hardy & vigorous with wide adaptability & early maturity. with broad leaves, high fibre content & poor quality juice. Cold tolerance
		B) Wild species	
		i) S. spontaneum	High fibre content, perennial grass with free, tillering & often aggressive rhizomes, long internodes with waxy bloom. Resistance to moisture stress, diseases.
		ii) S. robustum	It is perennial. Grow upto 10m. Stems are hard & pithy in center & contain little juice. Inflorescence rachis is without long hairs. Resistance to water logging.
3)	CHICK PEA	**A) Cultivated species**	
		i) Cicer arietinum	
		B) Wild species	
		i) C. reticulatum	Resistance to fusarium wilt, seed beetle, cold Ascochyte blight.
		ii) C. bijugum	Resistance to Ascochyte blight, cyst, nematode, seed beetle, cold.
		iii) C. echinospermum	Leaf minor, seed beetle, cold.
4)	SUNFLOWER	**A)Cultivated species:**	
		***i) Helianthus annus* L.**	

	B) Wild species:	
	i) H. argophyllus	Drought tolerance
	ii) H. praecox	Resistance to alternaria rust & downy mildew.
	iii) H. giganteus	Resistance to Sclerotia wilt.
	iv) H. petiolaris	Source for high oil content & for alteration of fatty acid composition, Cytoplasmic male sterility
	v) H. debilis	Source for salt tolerance
	vi) H. tuberosus	Source of resistance to leaf spot / blight, Downy mildew.
5) SAFFLOWER	**A) Cultivated species**	
	***i) Carthamus tinctorius* L.**	
	B) Wild species	
	i) C. oxyacantha	For resistance to leaf spot disease.
	ii) C. palaestinus Eig	For seed dormancy & earliness (drought avoidance)
	iii) C. paleestinus <u>*C. flavescens*</u>	For resistance to stem fly
	iv) C. flavenscens	For cold tolerance
	v) C. lanatus	For resistance to rust.

Chickpea :

Donors for different characters

Lines	**Characters**
ILC 72., 196, 201, 202, 3279, 3346, ICC 8920, 8922, G 130, Caina, NEC 249, P 336, 6099, 6308.	Tall upright growth
ICC 364, 552, 4945, 4951, 8284, P 271, 311, 1482, JG 62.	Double pods
ICC 11520, 11521, 12206, 12208, 12212, 12213, NEC 989, P 99, 431, 1198-1, ILC 194, 306, 2484, 2552, 2647	Multiseeds
ILC 95, 96, 97, 99, 100, 101, 148, 149, T 3, K 850, Rabat, L 144.	Bold seed
Multiple disease resistance	
ICC 12237, 11269	*Fusarium* wilt, dry root rot, black root rot
ICC 1069	*Fusarium* witl, Ascochyta blight, Botrytis gray mold
ICC 10466	*Fusarium* wilt, dry root rot, stunt
ICC 858, 959, 4918, 8933, 9001	*Fusarium* wilt, Sclerotinia stem rot
Insect resistance	
ICC 506, 1381, 4856, 5264, 6663, 7510, 7559, 7966, 10667, 10761, 10870	Pod borer
ILC 726, 1776, 2319, 2618	Leaf miner
G 109-1	Bruchids
P 636, H 208, PGM 442, BG 305, L 550, BG 405	Root rot nematode

Environmental stresses	
ICC 4973, 5003, 11514, BG 2, 209, 390, Ujjain 24, NP 57	Salt
ICC 4958, 10448, C 214, H 208, G 24	Drought
ILC 666, 668, 1071, 2487, 2505, 3081, 3287	Cold
Annigeri, 850-3/27, H 208	Heat
C 214	Frost

Lentil :

Important donors for A lentil Breeding Programme

Genotype	Source	Chief features
PL 406	Pantnagar	High yield, resistant to wilt and rust
Lens 830	IARI	Yield, earliness, drought tolerance
L 4076	IARI	Yield, adaptability
RAU 101	Dholi	Yield, adaptability
LG 231	Gurdaspur	Resistant to rust
LL 147	Ludhiana	Resistant to rust
PL 639	Pantnagar	Yield and resistant to rust
Sehore 74-3	Sehore	Yield and drought tolerance
L 3991	IARI	Drought tolerant
L 4163	IARI	Yield
JLS 1	Jabalpur	Drought tolerant and yield
LG 170	Gurdaspur	Yield
PL 77-2	Pantnagar	Wilt resistant
Vipasha	Pantnagar	Blight resistant
K 75	Kanpur	Yield

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EXERCISE NO. 13

VISIT TO SEED PRODUCTION PLOTS

Observations to be recorded by student :

1	Name of the crop and variety	
2	State of seed production	
3	Name of Producer / Grower	
4	Isolation method and Isolation distance	
5	Area of the crop	
6	Season of the crop	
7	Source of seed a) Tag size b) Tag colour	
8	Expected date of harvesting	
9	Expected yield (kg/ha)	

Certification Plot

1	Address of the seed certification agency where registration of plot made	
2	Date of Registration	
3	Fee of registration	
4	Field inspection	
5	Name of certification officer	
6	Expected date of harvesting	
7	Expected yield (kg/ha)	
8	Location of purchasing nit / marketing	
9	seed packing Rate of 1.0 kg packed seed	
10	Rate of 1.0 kg packed seed	
11	Name of the Purchaser	

EXERCISE NO. 14

VISIT TO AICRP PLOTS OF SAFFLOWER AND CHICKPEA

SAFFLOWER

Observations to be recorded by student :

1	Name of the crop	
2	Season of the crop	
3	Name of the trial	
4	Objectives	**1.** **2.** **3.**
5	Gross plot size	
6	Net plot size	
7	Spacing - Plant to plant	
8	Spacing - Row to Row	
9	Recommended Fertilizer dose	
10	Observations to be recorded	**1.** **2.** **3.** **4.** **5.** **6.** **7.** **8.** **9.**

B) CHICKPEA

Observations to be recorded by student :

1	Name of the crop	
2	Season of the crop	
3	Name of the trial	
4	Objectives	**1.** **2.** **3.**
5	Gross plot size	
6	Net plot size	
7	Spacing - Plant to plant	
8	Spacing - Row to Row	
9	Recommended Fertilizer dose	
10	Observations to be recorded	**1.** **2.** **3.** **4.** **5.** **6.** **7.** **8.** **9.**

EXERCISE NO. 15

VISIT TO AICRP PLOTS OF SUNFLOWER AND RABI SORGHUM

A) SUNFLOWER

Observations to be recorded by student :

1	Name of the crop	
2	Season of the crop	
3	Name of the trial	
4	Objectives	**1.** **2.** **3.**
5	Gross plot size	
6	Net plot size	
7	Spacing - Plant to plant	
8	Spacing - Row to Row	
9	Recommended Fertilizer dose	
10	Observations to be recorded	**1.** **2.** **3.** **4.** **5.** **6.** **7.** **8.** **9.**

B) *RABI* SORGHUM

Observations to be recorded by student:

1	Name of the crop	
2	Season of the crop	
3	Name of the trial	
4	Objectives	**1.** **2.** **3.**
5	Gross plot size	
6	Net plot size	
7	Spacing - Plant to plant	
8	Spacing - Row to Row	
9	Recommended Fertilizer dose	
10	Observations to be recorded	**1.** **2.** **3.** **4.** **5.** **6.** **7.** **8.** **9.**

SYLLABUS

Course:	AGS-606		**Credit:**	2(1+1)	**Semester-VI**
Course title:	Crop Improvement- II *(Rabi crops)*				

Theory

Centers of origin, distribution of species, wild relatives in different cereals; pulses; oilseeds; fodder crops and cash crops; vegetable and horticultural crops; Plant genetic resources, its utilization and conservation; study of genetics of qualitative and quantitative characters; Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, adaptability, stability, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional); Hybrid seed production technology of *rabi* crops. Ideotype concept and climate resilient crop varieties for future.

Practical

Floral biology, emasculation and hybridization techniques in different crop species namely Wheat, Oat, Barley, Chickpea, Lentil, Field pea, Rajma, Horse gram, Rapeseed Mustard, Sunflower, Safflower, Potato, Berseem. Sugarcane, Tomato, Chilli, Onion; Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods; Study of field techniques for seed production and hybrid seeds production in *Rabi* crops; Estimation of heterosis, inbreeding depression and heritability; Layout of field experiments; Study of quality characters, study of donor parents for different characters; Visit to seed production plots; Visit to AICRP plots of different field crops

Teaching Schedule

a) Theory

Lecture	Topic	Weightage (%)
1	Cereals –Wheat, oat and barley - Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	10
2	Pulses –Chickpea- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	8
3	Oilseeds –Sunflower and Safflower- Centers of origin, Distribution of species, Wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	10
4	Oilseeds –Linseed, Rapeseed and Mustard- Centers of origin, Distribution of species, wild relatives, Floral biology, Major	8

Lecture	Topic	Weightage (%)
	breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	
5	Fodders –Napier, Bajra, Sorghum, Maize and Berseem- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	5
6	Cash -Sugarcane - Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	6
7	Vegetable-Potato- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	5
8	Vegetable-Field pea- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	5
9	Horticultural crops-Mango, Aonla and Guava- Centers of origin, Distribution of species, wild relatives, Floral biology, Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional)	8
10-11	Plant genetic resources, its utilization and conservation	8
12	Adaptability and stability	5
13- 14	Hybrid seed production technology in Rabi crops -Sunflower, Safflower, Castor, Rabi Sorghum	12
15 - 16	Ideotype concept and climate resilient crop varieties for future- Wheat, Rice, Maize, Sorghum and Cotton	10
	Total	**100**

b) Practical

Experiment	Exercise
1	Emasculation and hybridization techniques in wheat, oat & barley
2	Emasculation and hybridization techniques in chickpea & lentil
3	Emasculation and hybridization techniques in field pea, rapeseed & mustard
4	Emasculation and hybridization techniques in sunflower
5	Emasculation and hybridization techniques in potato &berseem
6	Emasculation and hybridization techniques in sugarcane & cowpea
7	Emasculation and hybridization techniques in safflower
8	Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods
9	Study of field techniques for seed production and hybrid seeds production in Rabi crops
10	Estimation of heterosis, inbreeding depression and heritability
11	Layout of field experiments
12	Study of quality characters, study of donor parents for different characters
13	Visit to seed production plots
14	Visit to AICRP plots of Safflower & Chickpea
15	Visit to AICRP plots of Sunflower & Rabi sorghum

Suggested Readings:

Sr. No	Title of Book	Author/Authors	Publisher
1.	Crop Breeding and Biotechnology	HariHar Ram	KalyaniPublication New Delhi.
2.	Breeding of Asian Field crops	D. A. Sleper J.M. Poehlman	Blackwell Publishers
3.	Principle and Procedures of Plant Breeding Biotechnological and Conventional Approach	G. S. Chahal S. S. Gosla	Narosa Publishers House. New Delhi.
4.	Plant Breeding Principle and Methods.	B. D. Singh	KalyaniPublication New Delhi.

PRACTICAL MANUAL

AGS-607

Practical Crop Production--II

(Rabi Crops)

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Exercise No. 1

Introduction, Aims and Objectives of Practical Crop Production – II, Allotment of Plot and History of plot

Introduction: -

The course of Practical Crop Production – II in Agronomy is introduced in Fourth semester B.Sc. (Agri.) degree, from academic year 2007-08 commonly for all Agricultural Universities of Maharashtra State.

During this semester, each student will be given about 2 R area for raising one Rabi crop from cereal, pulses or oil seed group. The students are expected to work from sowing up to threshing and preparing produce for marketing. The students should also take all biometric observations from germination up to harvesting in the plot. The student's work will be evaluated on the basis of the performance of the students in completing the field operations, observations and maintenance of record, calculations etc. in the journal.

Aims and Objectives: -

1. To get actual practical experience in applying the improved technology for obtaining maximum production
2. To study the operations wise labour requirement and cost of each operation.
3. To study the input requirement for cultivation of allotted crop.
4. To study the constraints encountered for cultivation of crop under given set of field and climatic condition.
5. To study benefit cost ratio.
6. To develop confidence among the students.
7. To develop research attitude in the students.

Allotment of plot

Each student is allotted an area of 2 R for raising Wheat crop. Student should carry out all operations, record observations and do calculations of each operation to be carried out.

History of the allotted plot: -

i) Name of College :

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ii) Name of the block and plot No. :

iii) Location of plot :

iv) Area in ha/area :

v) Type of soil :

vi) Depth of soil :

vii) Fertility status of soil :

viii) Degree of slope of Land :

ix) Drainage condition of soil :

x) Source of water supply :

xi) Type of farming (Rainfed / Irrigated) :

xii) Crops suitable :

xiii) Distance from market :

xiv) Market and Transport facilities :

Crop History for last 3 years: -

Sr. No.	Year	Crop grown			Fertilizer applied (NPK kg/ha)		
		Kharif	*Rabi*	*Summer*	*Kharif*	*Rabi*	*Summer*

Assignment: -

Draw map of individual plot indicating the dimensions of plot and number of rows of crop sown.

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<u>PLAN OF LAYOUT FOR WHEAT</u>

Crop Variety: Block :

Date of Sowing: Plot No :

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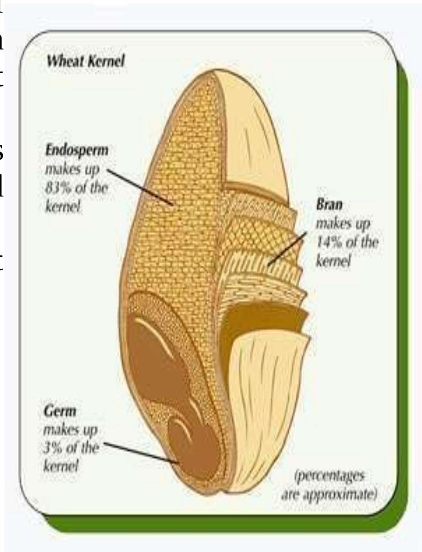
Exercise No. 02

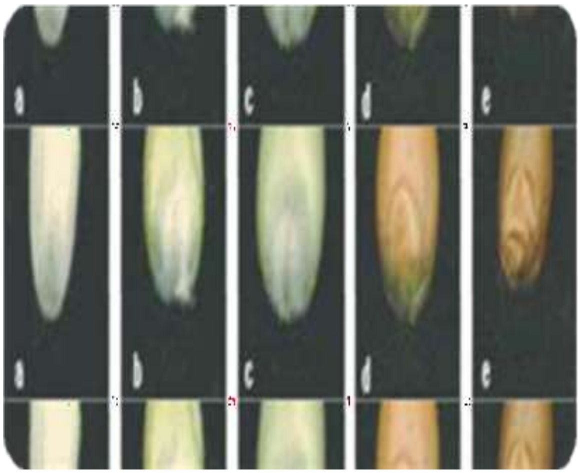
Study of seed production of rabi crops

SEED - Monocot species like wheat have caryopsis (cereal grains) as propagation units.Caryopses are single-seeded fruits in which the testa (seed coat) is fused with the thin pericarp (fruit coat).

Cereal grains have highly developed embryos and in cereal grains the triploid endosperm consists of the starchy endosperm (dead storage tissue) and the aleurone layer (living cells).

Organs of the cereal embryo are: coleoptile (shoot sheath),scutellum, the radicula &
the coleorhizae (root sheath).





Kernels at various stages during grain filling:

a) kernel at watery ripe
b) kernel at late milk
c) kernel at soft dough
d) kernel at hard dough showing loss of green color
e) kernel ripe for harvest

Physiological maturity:

When the kernels have attained maximum dry weight it is physically matured.Note the green color is gone from the peduncle and head parts.

Cultural Practices for Seed production of Wheat Land

requirement :

a) Land to be used for seed production of wheat should be:
b) Free of volunteer plants.
c) The field should be well drained,
d) Free of weeds.
e) The soil neither too acidic not too alkaline
Long interval of Crop rotation is desirable

Previous cropping

a) The crop should be planted on a field with a known history to avoid contamination from volunteer plants, noxious weeds and soil-borne diseases that are potentially seed transmitted.
b) A wheat seed crop should never immediately follow wheat, unless the wheat crop in the previous season was of the same variety and of the same or higher generation.
c) Two year rotation for flag smut and seed gall nematode is suggested where applicable.

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Isolation requirement

Normally a self-pollinated crop(Clistogamous)

- 1-4 % Cross pollination sometime occurs.
- It is sufficient to isolate seed fields with a strip of 3 meters all around which is planted with a non-cereal crop, or left uncroped.
- In cases where variety is susceptible to diseases caused by Ustilago spp. (eg. loose smut) an isolation distance of 180 meters between seed field and other fields of wheat is recommended
- As per Indian minimum seed certification standards require only 150 m isolation from other wheat fields where in loose smut infection is in excess of 0.1% in the case of foundation seed production and 0.5 % in the case of certified seed production.

Culture practices

Time of Sowing:

1. Long duration varieties like C 306 should be sown during the first fortnight of November.
2. Short and medium duration varieties like Sonalika, HD 1982 should be sown during the second fortnight of November.
3. The optimum time of sowing for wheat is when the mean daily temperature is 23±3°C and for good tillering temperature should range between 16-20°C.

Preparation of Land

1. Deep ploughing with a soil turning plough.
2. Running a harrow before the pre- sowing irrigation.
3. Give a light shallow ploughing or discing after pre-sowing irrigation.
4. Levelling is an important part of seed bed preparation.
5. Keep the seed bed free of weeds.

Source of seed :-***Obtain nucleus/breeder's/foudation seed from a source approved by the certification agency***.

Seed Rate:- The recommended seed rate for seed crop is 85-100 kg per ha. The seed should be treated with systemic fungicide to control loose smut.

Spacing : The row distance for seed crop should bekept at 22 to 23cm to facilitate rouging and inspection work. For late sown wheat reduce the line spacing to 15-18 cm

Crop Rotation :-Wheat is mainly grown in rotation with rice, sugarcane, arhar (pigeon pea) and sorghum, cotton, pearl millet, cluster bean, sorghum, groundnut,

Method of sowing

- The seed crop is sown in rowswith seed drill, or behind the plough in furrows.
- The depth of seeding should be 5 cm.
- Seed drill should be thoroughly cleaned and checked before use.
- Sowing of one variety should be completed before taking up another variety, to avoid mixture.
- If, for any reason, it has to be used for another variety, it should be thoroughly cleaned and checked so that not even a single seed of the previous variety is left.

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The recommended doses of fertilizers are:

1) 80 to 120 kg/ha nitrogen,
2) 50 to 60 kg/ha phosphorus
3) 40 kg /ha potash
4) 15 to 20 kg/ha zinc may be given at the seeding time (in case of deficiency).
5) Apply the whole of the phosphoric and Potassic fertilizers and half of nitrogenous fertilizers while sowing, or just before sowing.
6) Apply the remaining half of nitrogenous fertilizer at first irrigation.
7) In rainfed conditions, all the fertilizer should be applied at the time of sowing as basal.

Field Inspection

The best time to access cultivar purity is after ear-emergence when seed has started to fill. Latter inspection when glume and seed colour can be observed

Irrigation

- Depending on the soil, four to six irrigations may suffice.
- The first irrigation should be given at crown root initiation stage, about 30-35 days after sowing.
- Other irrigations should be given at late tillering, late jointing, flowering, milk and dough stages.
- Two to three extra irrigations may be needed on light soils.
- In case of zero tillage, first irrigation should also be applied similar to conventional tillage.
- Crown root initiation and heading stages are the most critical to moisture stress.

Interculture

- Timely weeding and intercultureare essential.
- Weed control by Periodic hoeing and weeding.
- For control of broad-leaved weeds spray 2-4 D at@ 0.5kg active ingredient per hectare in 750 liters of water after 25 to 30 days of sowing.
- For control of Phalaris minor or wild oats make a pre-emergence application of Penda methalin (stomp) @ 1 kg per ha in 750 liters of water or spray Isproturon @ 1 kg per ha in 750 liters of water after 35 days of sowing.

Roguing -Two or three roguings may benecessary

First roguing :- Just ahead of the flowering stage, or during flowering to remove any ff-type plants which are obvious at this state of growth.
Second roguing : Just after flowering is completed, and before the crop starts to turn colour.
Third roguing: should be done after the ear heads turn colour and start to mature.

Harvesting and Threshing

- Soon after maturity, the seed crop should be harvested to avoid shattering and losses due to uncertain weather.
- Most suitable stage is grain moisture of 20-25%.
- Mechanical harvesting is a common practice for seed

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- production fields.-

Breeder and pre-basic seed are harvested by plot combine and do not constitute manyproblems.

foundation and certified seeds have to be harvested with commercial combine harvesters.

The most critical factors to be considered are :

- seed moisture content,
- mechanical damage
- cleanliness of equipment.
- For seed crops, dry weather during ripeningand
- harvesting is essential.
- Threshing or combine harvesting at 16 to 19 percent moisture content reduces mechanical damage (Thompson, 1979).
- Harvesting may be done by sickle, Combine orreaper, and later the threshing with stationary thresher.
- Threshing should be done promptly.
- Threshing equipment should be cleaned after threshing other wheat varieties.
- The threshing floor must be thoroughly cleaned to prevent mixtures.
- Care must be exercised to ensure that laborers do not mix the harvested certified seed with other wheat on the farm.

Minimum Sample Weight for testing wheat Seeds(ISTA, 2007)

Maximum weight of Seed lot (Kg)	Submitted Sample (g)	Working Sample (g)	Working Sample for Counting of other Species (g)
30,000	1000	120	1000

- **Prescribed Seed standard for seed Certification(ISTA)**

Class of Seed	Off-type	Pollen shading	Object-able plant	Plant head affected by designated disease
Foundation Seed	0.050	-	0.010	0.10
Certified Seed	0.1	-	0.020	0.50

Seed Class	Germin ation %	Moisture	Pure seed (min)	Inert matter %	Other crop seed (max)	Object-able Weed Seed(max)
Foundation Seed	**85**	**12.0**	**98**	**2**	**10**	**10**
Certified Seed	**85**	**12.0**	**98**	**2**	**20**	**20**

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Exercise No. 03

Study of mechanization and Resource conservation in rabi crops

Zero tillage (ZT) technology plays an important role in the sustainable intensification of rice–wheat cropping system and adoption of better-bet management practices, such as timely crop establishment, in India. Nearly two decades ago, ZT was first introduced to help farmers reduce tillage costs and advance the planting time of wheat and other Rabi crops. In successive years, ZT marked the evolution of the concept of conservation agriculture in rice– wheat cropping systems. ZT now offers significant opportunities in cropping system optimization for greater system productivity, especially in the eastern Indo-Gangetic Plains of India. As the majority of farmers in rice–wheat cropping systems still burn the residues of the rice crop to enable their rapid disposal before wheat sowing, recent advances in ZT makes it possible to sow wheat successfully into heavy residues and facilitate the use of residues as mulches for weed suppression and moisture conservation. One example is the Happy Seeder that can seed wheat in heavy residue mulch of up to 8 to 10 t/ha without any adverse effect on crop establishment.

The productivity advantages of ZT wheat result from earlier planting (and thus avoiding terminal heat damage during
the grain filling stage), control of *Phalaris minor*, a major weed of wheat, better nutrient management and water savings.

- Other advantages include improved soil and water conservation, increased use of land through intensification of cropping systems, reduced labor and energy requirements, reduced equipment inventories, reduced wear and tear on tractors and equipment, and greater environmental benefits.
- ZT reverses the loss of soil organic matter that happens in conventional tillage. Improves soil quality and water retaining capacity by adding organic matter. As crop residues decompose, this creates an open soil structure that lets water in more easily, reducing runoff.
- Helps reduce CO_2 emissions and mitigate the adverse effect of global warming.
- ZT use leads to reduction in air pollution by minimizing crop residue burning.
- Improves the biological diversity of soil that increases the number of beneficial insects and keeps many insect pests in check.
- Establishing the wheat crop through zero tillage can be undertaken as a business Zero tillage (ZT) can be defined as the placement of seed into the soil by a seed drill without prior land preparation. A common definition of zero tillage (i.e., no-till) specifies that 30 percent of the soil surface should be covered by crop residues at the time of planting. Zero tillage improves the total productivity, meaning the efficiency of labor and capital used.

A tractor-drawn ZT seed-cum-fertilizer drill is the core of the technology, allowing wheat seed to be sown directly into unploughed fields with a single pass of the tractor, often with simultaneous basal fertilizer application, especially phosphorus. It can also be used for planting other crops like lentil, chickpea, mustard, green gram, rice and maize.

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A tractor-drawn ZT seed-cum-fertilizer drill

Combine Harvester - Is a machine which harvests the grain crops by comprising the three separate operation activities of harvesting. Those are:

1. Reaping { Harvesting }
2. Threshing
3. Winnowing these 3 operations are combined to form a single process in the combine harvester.

- FUNCTION OF COMBINE HARVESTER Feeding the standing crop to the cutter bar with the help of reel Cutting the crop Feeding the crop to threshing unit Threshing the crop Separating the husk from grains Cleaning the grains Conveying and storing the grain
- BEFORE OPERATING COMBINE HARVESTER Before operating the combine harvester in field we should check the followings in the field: Height of cutting, Moisture content , Crop condition ,Field condition.
- IDEAL REQUIREMENT'S OF A PERFECT COMBINE HARVESTER 1. Less broken grains 2. No grain loss on the ground at the cutter bar end 3. No grain losses at the back end of the harvesting unit 4. No un-thrashed grain 5. Should give clean grains 6. Machine should be capable of operation on crop even with higher moisture content 7. Machine should be capable of working on various crops 8. Easy to operate 9. Easy to maintain 10. Should consume less fuel

Combine Harvester

1.Standing crop 2.Reel 3.Cutter bar 4.Conveyor 5.Threshing drum 6.Sieves 7.Straw walkers 8.Unloader 9.Straw spreader

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Exercise No. 04

Study of physical and chemical properties of the allotted Plot to the students

Objects: - 1. To know the physical properties of the soil.
2. To know the chemical properties of the soil.

Introduction: -

Soil is defined as natural body consisted of mineral, organic matter and other living material in which plants grow. It is a natural body developed as a result of pedogenic process that takes place during and after weathering of rocks in which plants and other forms of life are able to grow.

Components of the soil: - Soil is mainly composed of

1. Mineral matter :- (45%) obtained from disintegration and decomposition of rocks.
2. Organic matter :- (5%) obtained by decay of plant residues and microbial tissue.
3. Water :- (20-30%) obtained from rains, snow, dew etc.
4. Air and gasses :- (20-30%) obtained partly from the atmosphere and partly as a result of reaction and microbial activities taking place in the soil.
5. Organisms :- Two types macro-organisms like rodents, worms, insects etc. and microorganisms like bacteria, fungi, actinomycetes etc.

A) Physical properties of the soil: - The physical properties of soil depend primarily on size. Shape and arrangement of its mineral and soil particles. The important physical properties of the soils are as under.

1) Soil Texture	2) Soil structure	3) Absolute-particle density
4) Bulk density	5) Porosity (Pore space)	6) Soil colour
7) Volume/weight of soil	8) Soil water	9) Soil consistency
10) Soil air	11) Soil temperature	12) Soil organic matter etc.

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B) *Chemical properties of the soil: -*

The chemical properties of soil are important, as they are closely related to the capacity of the soil to supply plant food nutrient's. They are largely govern the fertility of the soil. The important chemical properties of the soils are as under.

1) Soil reaction (Soil pH) 2) Cation and anion exchange capacity (CEC)

3) Soil solution 4) Soil colloids 5) Organic matter

C) *Classification of soils according to availability of nutrients and recommended dose of fertilizer.*

Sr. No.	Class of soil	Organic carbon (%)	Available NPK (kg/ha)			Dose of nutrients according to nutrient availability
			N	$P_2 0_5$	K_2O	
1	Very low	below 0.20	below 140	below 15	below 120	50% more
2	Low	0.21 – 0.40	140 – 280	16 – 31	121 – 180	25% more
3	Medium	0.41 – 0.60	280 – 420	31 – 50	181 – 240	As per RDF
4	Medium high	0.61 – 0.80	420 – 560	51 – 65	241 – 300	10% less than
5	High	0.81 – 1.00	560 – 700	66 – 80	301 – 360	25% less than
6	Very high	above 1.00	above 700	above 80	above 360	50% less than

D) Formula for calculation of available N, $P_2 O_5$ and K_2O in soil.

1) 1 hectare = 2240784 kg soil (15 cm depth)

2) Available N Kg/ha $= \dfrac{\%\ N\ (g) \times 2240784}{1000}$

3) Available P_{2os} Kg/ha $= \dfrac{\%\ P_{2os}\ (g) \times 2240784}{1000}$

4) Available K_2O Kg/ha $= \dfrac{\%\ K_2O\ (g) \times 2240784}{1000}$

A) *Physical Properties of the allotted plot:*

i) Soil Texture 1) Sand % ______________2) Silt % _____________3) Clay%____________

ii) Soil Textural class ______________________

iii) Soil structure __________________________

iv) True or Absolute sp. Gravity (Particle density) ____________________

v) Apparent specific gravity (Bulk density) __________________________

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vi) Pore space (Porosity) ________________________

vii) Soil consistency (Plasticity) ___________________

viii) Soil colour _________________________

ix) Soil temperature _____________________

x) Soil Water __________________________

1. Maximum water holding capacity: ___________________
2. Field Capacity: ___________________________________
3. Permanent Wilting point: __________________________
4. Available water capacity: __________________________

B) ***Chemical properties / Analysis of the allotted plot –***

i) Soil pH :

ii) E.C. of soils :

iii) Organic carbon :

iv) Available N :

v) Available P_2O_5 :

vi) Available K_2o :

vii) $CaCO_3$:

Assignment:-

1. Draw the diagram of equilateral triangle for determination of textural class of Soil
2. Suggest dose of N, P & K for Wheat crop according to available N, $P_2 O_5$ & K_2O of the allotted plot.

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Exercise No. 5

Study of package of practices for growing Wheat crop (Timely, Late and Rainfed)

Botanical Name: -*Triticum Spp.* **Family** :-Poaceae

A) ***Economic importance of Wheat: -***

1. It is important staple food in India next to rice.
2. Wheat contains 10 to 12% Protein, 57% Carbohydrate and 2-4 % lysine Wheat Protein is a good source of thiamine, nicotinic acid and other B-Vitamins.
3. It is used in preparation of baked products e.g.. Bread, flakes, cakes and buiscuits etc.
4. Wheat grain is also used in preparation of *Halwa, dalia, sevya, maida, Rava, upma, chapaties* etc.
5. Wheat protein contains characteristic substance 'gluten' which provides spongyness to the bread essential for bakers.

B) Origin and History: -It is originated from South Western Asia (Turkey). Aryan's introduce Wheat in India.

C) Area and distribution: - Wheat is grown all over world over an area of about 215 million ha. with a production of 584 million tones of grain. The important Wheat growing countries are China, India, USSR and USA. India ranks second in area and production of Wheat. Production of India in the year 2006-07 were 73 million tones. Important states growing Wheat are U.P, Punjab, Haryana, M.P., Bihar, Rajasthan and Maharashtra , U.P. stands 1st in area and production of Wheat but productivity was highest in Punjab.

D) ***Classification: -***

Wheat is annual plant which belongs to poaceae family and genus Triticum. Although as many as 18 species of Wheat have been described following four species are economically important and in cultivation.

1. ***Triticum aestivum*****: -**It is also known as soft Wheat or sarbati Wheat or bread Wheat. It is used for preparation of chapaty and bakery products.

2. ***Triticum durum*****: -** It is also known as Hard or Bansi or macaroni Wheat. It is used for preparation of *Suji, Rava, Sevya, Maida* etc.

3. ***Triticum dicoccum*****: -**It is also known as Emmer or khapli Wheat. It is used for preparation of South Indian dish e.g. Uppama. In Western Maharashtra it is used for preparation of "*Kheer*".

4. ***Triticum spherococcum*****: -**It is also known as Indian dwarf Wheat or Club Wheat.

Amongst these four ***Triticum aestivum*** is most important species accounting over 87 per cent of the total Wheat production of India followed by the durum Wheat (about 12%) and dicoccum Wheat (about 1 per cent.)

E) Crop morphology: -Wheat plant can be divided in two distinct parts viz root system and shoot system.

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1) ***Root system: - i) Primary root system or Temporary roots: -***

It forms at the time of germination and absorb nutrients for the young seedlings. As the plant growth progresses, the primary root system usually dies and is replaced by the more permanent secondary root system.

ii) Secondary root system or Permanent roots: - It arises at a point above the primary root system at the primary organ of absorption till maturity arises near the soil surface at the time of crown root initiation stage (usually, 21- 25 days after sowing).

2) ***Shoot system: -***

i) Stem: - The stem is round or cylindrical generally hollow except at the node.

ii) Leaves: - Leaf consist of four parts.

a) Leaf sheath: -It is basal part of leaf, it protect the growing point and auxiliary buds from weather.

b) Leaf blade: - It is flattened with parallel veined portion.

c) Ligule: - A membranous portion at the junction of the sheath and blade on the side of the leaf. The continuation of the sheath through the collar is known as ligule.

d) Auricle: - These are lobes of the leaf blade which extend down word on each side at the junction of the blade and sheath.

iii) ***Inflorescence: -***

The flowering portion of the Wheat plant is called ear or head but in botanical language, it is a spike. Spikelets are systematically arranged on the common axis. The central zigzag axis is the rachis. The spikelets are alternate.

Spilelet is composed of flowers called florets. The number of florets in a spikelet may vary from 1-5.

Florets: - The outer covering of a floret is made up of a lemma and a palea.

Kernel: - The typical Wheat kernel is from 3-10 mm in length and 3-5 mm in diameter.

F) Climatic requirement: - It requires cool, moist weather during its major portion of growing period followed by dry warm weather towards maturity. Temperature requirement at various growth stages of Wheat is as follows.

1) Germination- 20 - 25^{0}C 2) Tillering- 16 - 20^{0}C
3) Grain filling- 23 - 25^{0}C 4) Base temp- 5^{0}C

Wheat can be grown effectively where annual rainfall is 700 to 1600 mm. Rains after germination results into seedling blight. Warm and damp climate is not suitable. For maximum number of effective tillers, wheat requires about 55 – 60 days of cool climate during early stages of growth. When cloudy weather is coupled with high temperature then crop suffers from rust disease.

G) Soil: -Wheat prefers clay loam or loamy textural soils with good drainage and moderate water holding capacity soil pH Requirement for Wheat is 6.5 to 7.5. Information regarding Land preparation, seeds and sowing, Fertilizer management, inter-cultivation, water management, plant protection, harvesting and threshing are discussed in further exercises.

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H) *Rotations and inter cropping: -a) Crop Rotations:-*

i) Soybean -Wheat   ii) Paddy - Wheat   iii) Maize - Toria - Wheat

b) Intercropping:- Wheat + Mustard (9:1)

I) Varieties: - 1. Varieties of *Triticum aestivum*

Sr. No	Name of Variety	Duration (Days)	Grain Yield (Q/ha.)
i) Timely sown varieties			
1.	AKW 1071 (Purna)	110 – 115	30 – 35
2.	HD 2189	115 – 120	35 – 40
3.	AKAW 3722 (Vimal)	110 – 115	30 – 35
4.	DWR – 164	120	40 – 45
5.	Parbhani 51	120 – 125	38 – 40
6.	HD 2380	110 – 115	30 – 35
7.	Tall varieties: NI 747-19, NI 5643, NIAW-301	115 – 120	15 - 20
ii) Late sown varieties			
1.	AKW 381	90 – 95	35 – 40
2.	HI 977	105	30 – 35
3.	HD 2501	110	35 – 40
4.	NIAW 34	100	40 – 42
5.	DWR 195	110	35 – 40
6.	Kailas	115 – 120	32 – 35
iii) Rainfed varieties			
1.	NI 5439	115	10 – 12
2.	MACS 1967	105-110	8-10
3.	Ajintha	90 – 95	14 – 15

2. Varieties of *Triticum durum*.

a) Tall Varieties: - NI 146, Pusa – 6 , N-59, N-5749
b) Dwarf Varieties: - AKDW- 2997-16, HD-4502, Vijay, MACS- 2846, MACS-2496, MACS – 9, NIDW-15, , Panchvati

3. Varieties of *Triticum dicoccum* :-

NP – 202, DDK-1027, DDK-1009, NP-200

First dicocccum variety in Maharashtra have developed in the year 2008 by Agarkar Research Institute, Pune was **MACS-2971** (Yield : 50 - 52 Q/ha.)

* 3 gene dwarf verities in Wheat: - Heera, Moti, Arjun

* Triticale is cross between Wheat and Rye.

Assignment: -

1. Draw a diagram of Wheat plant and labeled the root and shoot parts.
2. Prepare leaflet on wheat cultivation
3. Explain crown root initiation in wheat.

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Exercise No. 6

Preparation of calendar of operation for Wheat

Objects: -

1. To study the various operations required for Wheat crop.
2. To know the labour unit required for various operations to be carried in Wheat crop.
3. To make timely arrangement of inputs and labours for carrying various operations for Wheat crop,
4. To know the cost required for various operations.

Definition: -

It is a statement of work schedule indicating the type of operations to be carri ed out in all farm crops during a specified period,

Method of preparation of calendar of operation: -

1. Prepare a list of crops to be grown in the farm.
2. List out chronologically all operations separately for each crop.
3. Fix up the time limit for each operation for various crops to be done month wise.
4. Fix up the priority of operations cropwise.
5. Estimate the manual and bullock power required for each crop.
6. All operations starting from preparatory tillage to threshing and winnowing for all crops should be included.
7. It should be in a such way that all operations scattered throughout the year and there should not be slack season.

Assignment: -

Problem: - Prepare a calendar of operation for growing wheat on an area of one ha and 2 R.

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Calendar of operation for Wheat:

Sr. No.	Month & Weeks No.	Operation to be carried out	Implement required	Labour unit					
				M		F		BP	
				2R	**1 ha**	**2R**	**1 ha**	**2R**	**1 ha**

Exercise No. 7

Study of preparatory, secondary tillage and seedbed preparation for Wheat.

Object: -

1. To know the various operations to be carried out in preparatory tillage operation for making friable and loose seedbed for easy and optimum germination and good growth of wheat.
2. To know the various implements, cost required for carrying preparatory and/secondary tillage operations.

Introduction: -

Tillage is defined as a physical manipulation of soil with suitable tools and implements to result good soil tilth for better germination and subsequent crop growth and yield.

Preparatory tillage: -

It includes proper leveling and mixing of F. Y. M. in the soil, planking and lay out of field for sowing the crop.

Secondary tillage:-

It includes harrowing and mixing of F.Y.M. in the soil, planking and lay out of the field for sowing the crop.

Land preparation for a Wheat: -

Wheat requires well-pulverized firm and fine but Compact seed bed. After the harvest of *kharif* crop the field should be deep ploughed with the help of M. B. Plough followed by 2 to 3 harrowing. The stubbles and residues of previous crop be collected and burnt off and make field clean. Planking is done after each harrowing to level the seedbed. Before last harrowing apply 10 to 15 t of FYM/ha.

Preparation of sara or broad bed: -

For irrigated Wheat, field is divided into no. of strips called as sara or broad furrow with the help of sara yantra. Width of sara should be 2 to 4 m, however, length depends upon slope and type of soil. (6 to 8 m).

On shallow and medium soil the length of sara should be less. On leveled and deep clay soils the length may be more. These strips are divided into flat beds by preparing furrows across the sara with the help of ridger, which may serve as irrigation channels. The bunds of the saras are mended with manual labour with the spade.

Observations to be recorded: -

Sr No.	Operation carried out	Date of Operation	Labour used			Implement used	Area covered (m^2)
			M	**F**	**BP**		
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							

Calculations: -

i. Calculate total labour unit required per plot for preparatory tillage.

ii. Calculate labour unit required per ha. for seedbed preparation.

iii. Calculate total cost required for seedbed preparation.

  a. Per plot

  b. Per ha.

Exercise No. 8

Sowing and seed treatment of Wheat

Objectives: -

1. To know the various seed treatments to be carried out in Wheat.
2. To know the cost of seed treatment to Wheat.

Introduction: -

Seed treatment is defined as a process of treatment of seed with various substances i.e. water, fungicides, growth regulators, nutrient solutions or any other physical treatment before sowing the seed for various purposes or objectives.

Objectives of seed treatment: -

i. Preventive control measure against pest & diseases-
ii. Breaking of seed dormancy
iii. Convenience in sowing
iv. Quicker germination
v. For N fixation
vi. Enhancing crop growth

Seed treatments to Wheat Seed: -

1 Thiram @ 3g/kg seed to control fungal diseases.
2 Vitavax @ 2g/kg seed or solar heat treatment to control loose smut.
3 Azotobactor @ 25g/kg seed to fix atmospheric nitrogen asymbiotically.

Procedure for seed inoculation with Azotobactor: -

Prepare a Jaggery solution by adding 125 of Jaggery in 1.25 litre of water. Boil the solution, cool it and add 250 g. Azotobactor culture in Jaggery solution. Stir it properly and pour on the 10 kg seed. Treat the seed thoroughly and dry under shade before sowing.

Observation and Calculations: -

i) Calculate the required quantity of seed.

i. Per plot ……………… ii. Per ha. ………………

ii) Calculate required quantity of thirum / Azotobactor.

i. Per Plot ……………… ii. Per ha ………………

iii) Calculate labour unit required / plot

a. Labour required for treating the seed / plot
b. Time required to treating the seed / plot

i) Calculate labour units required / ha

ii) Calculate cost of thiram required

i. Per Plot ……………… ii. Per ha ………………

iii) Calculation total cost required for seed

i. Per Plot ……………… ii. Per ha………………

Sowing of Wheat: -

a) Sowing time: -

Rainfed - 15 – 30th October.
Timely sown irrigated Wheat - 01 – 15th November.
Late sown irrigated Wheat - 15 Nov. to 15th December.

Delayed sowing causes reduction in yield.

b) Method of sowing: - Drilling with the help of two bowl seed drill or seed cum ferti drill.

c) Seed rate: -

1. Rainfed Wheat - 75 – 80 kg/ha.
2. Timely sown irrigated Wheat- 100 to 125 kg/ha.
3. Late sown irrigated Wheat - 125 to 150 kg/ha.

d) Depth of sowing: -

1. Rainfed Wheat (Tall varieties) - 8 – 10 cm.
2. Irrigated Wheat - 4 – 5 cm.

Mexican dwarf varieties of wheat should be sown at shallow depth because of short coleoptile length.

e) Spacing: -

i) Rainfed and timely sown irrigated Wheat - 22.5 cm bet^{n} row to row.

II) Late sown irrigated Wheat - 15 – 18cm bet^{n} row to row.

f) Plant population / ha: - 18 – 20 lacs/ha.

g) **Sowing direction:-** North-South

Observations and calculations: -

1. Date of sowing :-
2. Method of sowing :-
3. Row to row spacing :-
4. Variety :-
5. No. of rows per plot :-

Labour unit (Sowing)

i) No. of labour engaged / plot

ii) Time required for sowing / plot

8) Calculate labour unit required / plot

9) Calculate labour unit required / ha

10) Calculate time required / ha

a. Cost of seed + cost labour unit

11) Calculate sowing cost including labour cost / ha

Assignment: -

Calculate the seed required for your plot area if the seed rate is 100 kg/ha.

Exercise No. 9

Study of Integrated Nutrient management of Wheat.

Objects: -

1. To know the nutrient requirement of Wheat.
2. To know the method and time of application of nutrients to Wheat crop.
3. To know the labour unit cost and cost of nutrients requirement.

Nutrient management of Wheat: -

Apply 10 to 15 t of FYM or compost before last harrowing. NPK dose for Wheat is as follows.

1. Rainfed Wheat	-	40 : 20 : 20 kg NPK/ha.
2. Timely sown irrigated Wheat	-	120 : 60 : 60 kg NPK/ha.
3. Late sown irrigated Wheat	-	80 : 40 : 40 kg NPK/ha.
4. Under limited irrigation	-	60 : 30 : 00 kg NPK/ha.
5. For Tall Niphad varieties	-	75 : 50 : 50 kg NPK/ha.

For rainfed Wheat full dose of NPK should be applied at the time of sowing. However, under irrigated condition half dose of nitrogen and full dose of P & K should be applied at the time of sowing with the help of two bowl seed drill. Remaining half dose of nitrogen should be broadcasted at the time of first irrigation i.e. 18 – 21 DAS.

For Integrated Nutrient management of Wheat the seed should be inoculated with Azatobacter and PSB 250g per 10 to 12 kg of seed.

Observations and calculations: -

i) Calculate quantity of fertilizer required (Basal dose)

a) Per plot - Urea___________SSP______________MOP____________

b) Per ha - Urea___________SSP______________MOP____________

II) Calculate quantity of fertilizer required for top dressing

a) Per plot - Urea_____________

b) Per ha - Urea_____________

III) Calculate cost of fertilizer application

a) Per plot - _______________

b) Per ha - _______________

Calculation for fertilizer for wheat crop on the basis of soil test report.

Available N = 190, P2O5 = 14 kg, K = 500 kg

Sr. No	Nutrient	Formula	Nutrient required for 45 Q/ha yield on the basis of soil test report.
1.	N Kg/ha through fertilizer.	(7.54 x Expt. yield q/ha)	(0.74 x available N kg/ha) N-199 kg. Urea- 432 kg.
2.	P_2O_5 kg/ha through phosphatic fertilizer	(1.90 x Expt. Yield q/ha)	(2.88 x available P_2O_5 kg/ha) P_2O_5 - 45kg, SSP-280 kg
3.	K2 kg/ha through Potosh fertilizer	(2.49 x Expt. Yield q/ha)	(0.22 x available K_2O kg/ha) K-2kg, MOP-5kg

Assignment: -

1. Calculate quantity of Urea, SSP and MOP for Wheat crop grown on 2 R area.
2. Calculate quantity of 18:18:10, Urea and MOP for late sown irrigated Wheat grown on 1 ha area
3. Calculate dose fertilizer for your plot on the basis of soil test report.

Exercise No. 10

Study of water management to Wheat

Objects: -

1. To know the water requirement of Wheat.
2. To know the critical growth stages of Wheat for irrigation.

Management of irrigation water is most important in Wheat. Adequate soil moisture is required for normal development of Wheat plant at all the stages of growth.

Irrigation Layout: -

For irrigated Wheat, after the seedbed preparation, saras (Broad bed) are prepared dividing the field in the number of strips with the help of “sara yantra”. The width of sara should be 2 to 4 m. The length depends upon and type of soil. (Generally, 6 to 8 m.)

Water requirement: - 45 to 50 cm

Irrigation scheduling: -

Based on different approaches for irrigation scheduling recommendations for Wheat are as follows.

1) Soil moisture depletion Approach: - Generally Wheat is irrigated at 50 to 75 per cent depletion of soil moisture.

2) Climatological approach: - In this approach, a known amount of water (IW) is applied when cumulative pan evaporation (CPE) reaches a pre-determined level. The amount of water given at each irrigation ranges from 4 to 6 cm. according to soil type. Generally, irrigation is scheduled at 0.75 to 0.8 ratio with 5 cm of irrigation water.

3) Critical growth stage approach: - Critical growth stages of Wheat are crown root initiation, maximum tillering, late jointing, flowering, milk stage and dough stage. If irrigation is applied at every critical growth stage, maximum yield can be achieved.

Irrigation and water management to Wheat: -

For normal growth and development, Wheat requires about six irrigations, excluding pre-sowing irrigation. Depth of each irrigation should be 6 cm. The scheduling of irrigation based on critical growth stages is as follows.

Sr. No.	Growth Stage	Days after sowing
1.	Crown root initiation	16 to 20
2.	Maximum tillering	30 to 35
3.	Late jointing	45 to 50
4.	Flowering	65 to 70
5.	Milk stage	80 to 85
6.	Dough stage	95 to 100

If the quantity of irrigation water is limiting factor, it should be managed as under.

1. Only one irrigation - 21 DAS
2. Two irrigations - 21 and 65 DAS
3. Three irrigations - 21, 42 and 63 DAS
4. Four irrigations - 21, 42, 63 and 84 DAS

Observations: -

1. Variety :
2. Date of sowing :
3. Critical growth stages :
4. Date of irrigations :
5. Water measuring device used :
6. Area to be irrigated :
7. Time required in (hrs.) :
8. Discharge / second (lit) :
9. Total water required (lit.) :

Assignment: -

1 Identify critical growth stages of Wheat, draw diagrams and labeled.

2. Calculate cost of each irrigation and total irrigations for 1 hectare and for 2 R area.

Exercise No. 11

Title: - Determination of germination/emergence percentage of Wheat.

Objects: - 1. To know the germination percentage of seed.
2. Adjust seed rate for maintaining optimum plant population per hectare.

Germination is the development of seedling from the seed embryo which is able to produce a normal plant under favorable conditions. Plant population per hectare is the most important production factor for obtaining higher yield. For this purpose grower must know the germination percentage of seed which is being used for sowing. Seed rate can be adjusted according germination percentage for obtaining optimum plant population.

Types of germination: -

i) Epigeal: - In which cotyledons come above the soil surface and generally become green and photosynthetic.

ii) Hypogeal: - In which cotyledons do not come above the soil surface.

Methods of testing seed germination.

1. Paper method: -

The paper should be soak in water for 2 - 4 hours to moisten it evenly and to remove water soluble toxic substances. If present, paper may be used for seed germination in one of the several ways listed below:

a) TP (Top of paper)
b) BP (Between paper)
c) PP (Pleated paper)

When seeds are germinated in paper first count may be taken after 4 days. Final count may be taken after 12 days. If seedlings are weak then the germination period may be prolonged. By taking final count germination percentage may be calculated.

$$\text{Germination \%} = \frac{\text{Actual no. of germinated seed}}{\text{No. of seed put for germination}} \times 100$$

2. *Petri-dish method: -*

Two blotters or filter papers are placed on the bottom of the Petri-dish and they are soaked with water. Number of blotters can be increased or decreased according to the need of water by seed during germination and size of the seed. A convenient number of seeds, ranging from 10-20, depending upon their size are placed on the surface of water-soaked blotters in the Petri-dish. The kind of seed, date and time of seed soaking are written on the glass-over of Petri-dish with the help of a glass marking pencil. Usually, the germination percentage is calculated and reported on the basis of the results of germination of about 100 to 200 seeds.

3) Sand method: -

Sand is used as substrate for testing seed for germination. Sand is to be put in a metalytic or plastic boxes. Then moist the sand and put seeds uniformly in a moist sand cover the seed with moist sand having 1-2 cm layer. Then required amount of water to be added to the sand boxes daily till germination takes place. Then normal seedlings should be counted and calculate germination percentage.

Emergence percentage: -

Emergence percentage is calculated after sowing the seeds in the field when germination completely takes place. After sowing the when complete germination take place than number of plants emerged in the plot are to be counted physically. Then on the basis of theoretical plant population and actual emerged seedlings, emergence percent is to be calculated.

Observations and calculations: -

1. Date of sowing
2. Date of observation
3. Plot size
    a) Length of plot row
    b) Spacing between two rows
    c) Spacing between two plants
    d) No. of lines/plot:
4. Calculate theoretical plant population/plot (A) ___________________
5. Actually No. of seedling emerged-/Plot (B) ___________________
6. Calculate emergence % {(B/A) x 100} ___________________

Exercise No. 12

Study of growth and yield contributing attributes in Wheat.

Objects: -

1. To study various growth stages of Wheat crop.
2. To study growth and yield attributes of Wheat.

Growth stages of Wheat: -

Different growth stages of Wheat are as follows

1. Germination and emergence
2. Seedling
3. Crown root initiation.
4. Tillering.
5. Jointing
6. Flag leaf stage / Boot leaf stage
7. Boot stage.
8. Flowering
9. Milk stage
10. Dough stage
11. Maturity

Plant growth observations in Wheat: -

i) Growth contributing characters: -It includes plant height (cm), No. of tillers/plant, No. of leaves/plant etc.

ii) Yield contributing characters: - It includes, No. of earheads per metre row length, No. of spikelets per earhead, length of earhead, No. of grains per earhead, test weight (1000 grains weight), yield / plant (Grain & straw yield) etc.

Procedure for recording observations: -

Growth observations should be taken at fixed periodic interval i-e. at 30, 60, 90 DAS and at harvest. Select 5 plants randomly from a plot label these selected plants and record periodic observations.

Growth observations of Wheat crop: -

Plant No.	Plant height (cm)				No. of leaves/ plant				No. of tillers/plant			
	30	60	90	At Harvest	30	60	90	At Harvest	30	60	90	At Harvest
1												
2												
3												
4												
5												
Total												
Mean												

Observations of yield contributing characters: -

Plant No.	Length of earhead (cm)	No. of spikelets/earhead	No. of grains/spikelet	No. of grains/earhead	Yield (g)	
					Grain	Straw
1						
2						
3						
4						
5						
Total						
Mean						

Other observations: -

i) Date of emergence :

ii) Date of seedling stage :

iii) Date of Max. tillering :

iv) Date of boot stage :

v) Date of 50% flowering :

vi) Date of harvesting :

vii) Grain yield/plot (kg) :

viii) Grain yield/ha (kg) :

ix) Straw yield /plot (kg) :

x) Straw yield/ha (kg) :

xi) Grain to straw ratio :

Assignment: Define all the growth stages of wheat.

Exercise No. 13

Study of interculturing and weed management in Wheat

Objects: -

1 To Know the method, cost of interculturing required to Wheat crop.

Inter cultivation in Wheat: -

1) Hoeing: - In Wheat, only one hoeing with hand hoe or slit blade hoe is recommended at 15 DAS.

2) Weeding :- Critical crop weed competition period in Wheat is 30 to 40 DAS. Hand weeding should be followed at 20 and 40 DAS. For effective control of weeds following herbicides are recommended for wheat crop.

Name of Herbicide	Application Rate kg. (a.i/ha)	Time of application	Weeds controlled
1. Isoproturon	1.0 Kg	Pre-emergence or post-emergence at 25 – 30 DAS	Broad and narrow leaved weeds
2. 2 4 – D	1.0 to 1.25 Kg	Post-emergence at 25-30 DAS	Broad leaved weeds

Note: - 1) Use 700 lit. of water per ha. for soil application and 500 lit of water for foliar spray.
2) Select only one herbicide

Weeds Observed in Wheat crop: -

a) Monocot weeds: -

Phasalis minor is considered as mimicry weed in Wheat. Besider this following monocot weeds are observed in Wheat.

1) Wild oat - *Avena fatua*
2) Lavala / Nagarmotha - *Cyperus rotundus*
3) Haryali - *Cynodon dactylon*

b) *Dicot weeds observed in Wheat: -*

1) Bathua - *Chenopodium album*
2) Krisha neel - *Anagallis alba*
3) Senji - *Melilotus alba*
4) Chandvel - *Convonvulus arvensis*

5) Piwala Dhotra	-	*Argemone mexicana*
6) Ghol	-	*Portulaca Oleraceae*
7) Congress Weed	-	*Parthenium hysterophorus*
8) Badi dudhi	-	*Euphorbia hirta*
9) Math (chawali)	-	*Amaranthus viridis*
10) Ankri	-	*Vicia sativa*

Observations and calculations: -

1. Identify and list the weeds observed in your plot.
2. Calculate the labour required for weeding / plot & per ha.
3. Calculate total cost of weeding per plot & per ha.

Exercise No. 14

Title: - Study of Integrated insect, pest and diseases management in wheat

Object: - 1) To identify and control the various diseases and pest in Wheat.

Insect pests: -

Wheat is affected by a number of insect, pest and rodents.

1) Stem borer:

Attack of stem borer is observed in Wheat at heading stage.

Control measure: - 1) Uproot affected plants & burnt it.

2) Spray Carbaryl 50% @ 40g/10lit. of water

2) Termites: -

Termites damage the crop soon after sowing and sometimes near maturity. Infestation is heavy under unirrigated condition and in the fields where undecomposed FYM is applied before sowing.

Control measure: -

Mix 5% Aldrin dust @ 25kg/ha at the time of last harrowing before sowing.

3) Brown Wheat mites, Aphids and Jassids: -

These leaf sucking inseds results into discolouration of leaves.

Control measure: - **1.** Rogor @ 10g/10lit of Water.

Rodents: - Field

Rats: -

They cause heavy loss to Wheat crop and do considerable damage to the harvested crops lying in stacks in the field.

Control measure: -

1) Use poison bait to control rats (50 parts Wheat or maize floor + 1 part Zinc phosphide + little edible oil) OR

Fumigate the burrows of rats in the morning time with aluminum phosphide @ 1 tablet of 0.5g per small burrow or 3.0g per large burrow.

Diseases of Wheat: -

1) Rusts: -

a) Brown Rust : *Puccinia recondita tritici*

b) Yellow Rust : *Puccinia striiformis*

c) Black Rust : *Puccinia graminis tritici*

Control measure: -

1) Grow resistant varieties viz. HD 2733, HD-2428.
2) Avoid late sowing of long duration varieties.
3) Spray Zineb or Mancozeb (Dithane M-45) @ 25g 1 lit of water.

2) Loose smut: -*Ustilago nuda tritici*.

Control measure: -1) Solar heat treatment or seed treatment with vitavax @ 2g/kg seed before sowing.

3) Karnal Bunt: - *Neovassia indica*

C.M. 1) Seed treatment with Agrosan GN @ 2.5g/kg seed.

2) Avoid excessive irrigation particularly during flowering of Wheat.

4) Alternaria leaf blight: - ***Alternaria triticina***

C.M. 1) Seed treatment with vitavax @ 2.5g/kg seed.

2) Applying adequate fertilizer and irrigation.

3) Spraying Zineb or Dithane M-45 @ 25g/ 10 lit of water.

Assignment:

1. Identify diseases and pests in your plot. Write their nature of damage.

Exercise No. 15

Study of crop maturity signs and harvesting of Wheat.

Objects: -

i) To know the maturity and proper time of harvesting of wheat crop.

ii) To know the method of harvesting of wheat crop.

iii) To know the labour cost required for harvesting of wheat crop.

Introduction: A) Maturity sings: -

The maturity period in Wheat varies from variety to variety.

Early Varieties	-	90 – 95 days
Medium duration	-	105 – 110 days
Long duration	-	120 to 130 days

Signs of maturity in Wheat are as follows.

1) Leaves and stem turn yellow and becomes fairly dry.

2) Moisture content in grains 25 – 30 %

To avoid loss in yield, crop should be harvested before it is dead ripe. Delay in harvesting may result in damage by rats, birds, insects, shattering and lodging. Timely harvesting ensures optimum grain quality and consumer acceptance.

B) Harvesting: - Harvesting of Wheat normally done with sickles by hand. The crop is cut at about 15 cm from the ground level. It is tied into bundles and allowed to dry for 4 to 5 days.

Observation: -

1) Date of harvesting :

2) Age of crop at harvesting :

3) Labour required per plot for harvesting :

4) Time required per plot for harvesting :

5) Weight of plants immediately after harvest (W1) :

6) Weight of harvested produce after drying (W2) :

7) Loss in moisture (W1-W2) :

8) Calculate the loss of moisture % :

Calculations: -

1) Labour unit/plot for harvesting- 2) Labour unit/ha harvesting-

3) Cost of harvesting/plot- 4) Cost of harvesting/ha-

Assignment: - Identity signs of maturity on your plot.

Exercise No. 16

Threshing, drying, winnowing, storage and preparation of produce for marketing of Wheat

Objective:

i) To know the method of threshing of wheat crop.

ii) To know the labour cost required for threshing and marketing of wheat crop

Threshing in Wheat: -

It can be threshed by trampling under bullock feet or by tractor Now-a-days power thresher are used for threshing. In mechanized farming combine harvester cum thresher can be used which can do harvesting, threshing and winnowing of Wheat crop in single operation. Threshing be done with mechanical thresher having either wire loop cylinder or rasp bar cylinder. (550-600 RPM)

Harvest index:

It is the ratio of economic yield to total biomass production.

$$H.\,I. = \frac{\text{Economic Yield}}{\text{Biological Yield}} \times 100$$

Winnowing: -

It is process of separating grains from the threshed material or bhoosa using natural or artificial wind. When threshing machines are used, winnowing is done simultaneously with threshing.

Drying and storage: -

After winnowing, seed are dried in the sun up to moisture percentage of 10 to 12% for safe storage seeds are dried under sunlight to bring moisture content in grains up to 12%.

Preparation of produce for marketing:

Before marketing or storing the grains are dried in bright sunshine. Again cleaning and grading is adopted. The produce is filled in gunny bags or bins and then stored in rat proof godown.

Observation & Calculation: -

1) Date of threshing

2) Method of threshing

3) Time required for threshing per plot

4) Time required for threshing per ha

5) Labour required for threshing and cleaning/plot

6) Labour required for threshing and cleaning/ha

7) Grain yield per-plot

8) Cost of threshing/cleaning/plot

9) Cost of threshing / cleaning/ha

Assignments:

Calculate harvest index of wheat from following data.

1. Grain Yield : Per plot ___________Per ha. _____________
2. Straw Yield: Per plot ___________Per ha. _____________

2. How value addition can be done in wheat after harvesting.

3. What are the cares are to be taken while storing and marketing of wheat.

Exercise No. 17

Study of cost of cultivation of Wheat and working out net returns per student

Objectives: -

i. To study the cost per unit area required for various operations
ii. To study the total cost of cultivation per plot and per ha.
iii. To study the cost of production per unit of produce of Wheat
iv. To study the benefit cost ratio of Wheat
v. To study the cost of various inputs required for Wheat

Introduction: -

Cost of cultivation is a total expenditure incurred to any crop till the produce sold in the market. It is calculated by taking into consideration all the tillage operations. Following are the terms required for finding out the expenditure for production of crop.

1. **Preparatory tillage: -** Charges required for all essential preparatory tillage operations like, ploughing, harrowing, clod crushing, Leveling etc.

2. Manures & fertilizers: - Cost required for purchase of manures, fertilizer & its applications is taken into account.

3. Seeds and sowing:- Cost of seed & its sowing & material required for seed treatment.

4. Irrigation:- Irrigation charges depend upon season & duration of the crop and source of irrigation Number of irrigation’s given are taken into consideration and charges incurred on it are calculated.

5. After tillage: - Expenditure required for after tillage operations like hoeing, weeding, plant protection measures and any other special operation carried after sowing are included under this item.

6. Harvesting & preparing for market: - This includes the charges required for harvesting of crop, threshing, cleaning drying & preparing it to market.

7. Marketing charges: - Generally, marketing charges are calculated 50 paise per 100 kg of produce & by product if any while calculating marketing charges. Labour required for grading the produce, transporting to market, charged by municipality and *hamali* charges are also included under this item.

8. Supervision charges: - These are calculated 10% on the total cost of production i.e. from preparatory tillage up to marketing of produce.

9. Interest on capital: - It is based on the half-life period of the crop. It is calculated (a) 16% depending on that half period of crop.

10. Rent of land: - It depends upon the crop i.e. unirrigated of irrigated. It varies from Rs. 60 to 250 per ha for unirrated to irrigated respectively.

11. hire charges for application & depreciation charges: - It involves the higher charges of appliances such as implements, tools, sprayers dusters etc. required throughout period of crop.

COST OF CULTIVATION OF IRRIGATION WHEAT:

Sr. No.	Operation	Labour required			Cost (Rs.)	
		M	W	BP	Per plot	Per ha.
I	**Preparatory**					
	a) ploughing (1)					
	b) Harrowing (1)					
	c) Cold crushing (1)					
	d) Harrowing (2)					
	e) Collection of stubbles					
	f) Planking					
	Total					
II	**Seed and sowing**					
	a) Cost of seed @ Rs. 16 /kg					
	b) Sowing with two bowled seed drill					
	c) Covering the seed					
	d) Preparation of Saras, water channel					
	Total					
III	**Manure and fertilizers**					
	a) Cost of F.Y.M. 5t @ Rs. 300/t					
	b) Transport of F.Y.M.					
	c) Spreading of F.Y.M.					
	d) Cost of Urea					
	e) Cost of S.S.P					
	f) Cost of M.O.P. s					
	g) Top dressing of Urea					
	Total					

IV	**After care**					
	a) Gap filling					
	b) Hoeing (2)					
	c) Weeding					
	d) Irrigation (6)					
	e) Irrigation charges @ Rs. 100/irrigation for 6 irrigation					
	Total					
V	**Plant protection**					
	a) Seed treatment of thirum @ 3 g/kg for Thiram cost @ Rs. 17/100g packet					
	b) Treating seed with thium					
	C) Spraying (2) cost of dithane M – 45 – 2kg @ Rs. 110/500 g.					
	d) Labour charges for Spraying (2)					
	e) Foliar spray of Urea (2%)					
	Total					
VI	**Harvesting**					
	a) Cutting the plants & trying the bundles					
	b) Threshing with machine @ Rs. 50/q					
	c) Drying, cleaning, bagging					
	Total					
VII	**Marketing**					
	a) Grading (sieving) and transport					
	b) Octroi and other charges					

ABSTRACT

Sr. No.	Item of expenditure	Cost/plot (Rs.)	Cost/ha (Rs.)
1.	Preparatory tillage		
2.	Seeds and sowing		
3.	Manures and fertilizers		
4.	After care		
5.	Plant protection		
6.	Harvesting		
7.	Marketing		
	Total Cost of production (1 to 7)		
8.	Supervision charges (on basis of cost of production)		
9.	Interest on working capital @ 15% for ½ the life period of crop i.e. 60 days		
10.	Hired charges on implements and appliances		
11.	Land rent and taxes		
	Cost of cultivation (A) – (1 to 11)		
12.	**Yields (q)**		
	i) Grain - @ Rs. 850/q		
	ii) Bhusa @ Rs. 100/q		
	Total income (Receipt) = (B)		
13.	**Cost per (qts)** = Total Cost (A) / Yield (Main Produce)		
14.	**Net profit (C) =**		
15.	**B:C ratio =** Profit (C) / Cost (A)		

Exercise No 18

Study of post-harvest technology of wheat

Objectives: -

i. To study the processing, cleaning, grading and packing procedure.
ii. To study the value addition technology.
iii. To study the cost of Wheat as per gradation.

Processing

- After a seed crop has been harvested, the seed, if necessary, has to be dried and cleaned.
- For wheat seed cleaning, mainly screens, indented cylinders and air screen cleaner are used
- Screens separate based on the width and thickness; a width (or diameter) separation is obtained by round screens, while for thickness separation oblong screens are used
- Indented cylinders carry out length separation; the indents (cells or pockets) in the cylinder will, depending on their size, lift the seeds, which fit in the indents.
- Air separates seeds according to their behavior in an air stream (seed density) . The most important characteristic is the weight; light particles (dust, chaff, glumes or empty or partly filled seeds) will be lifted, whereas the heavier seed will fall down through the air stream.

Pre-cleaner- It has one air channel to remove light material, one top scalping screen toremove large particles and one bottom grading screen to remove small particles.

Dryer- If wheat seed is above 11 to 12 percent moisture, it is dried before it goes into bulk storage or processing.

Air-screen cleaner

- This is the basic cleaner, usually with two air channels and, preferably, four screens.
- The first air channel removes dust and light materials as the seed falls from the feed hopper.
- The second air channel removes light seed and materials after the seed passes through the last screen.
- Screen configurations vary considerably, one or two top or scalping screens remove particles larger than the good seed, and one or
- two bottom or grading screens remove particles smaller than the goodseed.
- Because the average size of wheat seed varies according to the growing conditions, standard screen sizes cannot be
- recommended..
- In general size of Screen aperture for all wheat variety is :

Length separator

- A length separator is almost always used to clean wheat seed. By using the proper machine configuration, shorter or longer undesirable materials (such as broken grains, weed seeds, oat, barley, etc.) are removed. Broken grains and weed seeds, which are shorter than the good seed, are removed by using cylinders with smaller indents.
- Larger impurities can be removed by using a cylinder with indents that lift all good seed, but contaminants (wild oats, oats or barley grains and unthreshed glumes) remain in the cylinder.

Gravity separator

- The gravity separator classifies a seed mixture mainly according to density or specific gravity. It can be used to remove unthreshed glumes and soil particles, which have similar sizes to wheat but different weights.
- Another application is the removal of weevil-infested grains from the seed lot and upgrading seed (in order to improve germination).
- Furthermore, wild oats and some barley may be removed from the wheat seed lots.

Treater

- Wheat seed should, if necessary, be treated with the appropriate fungicide to protect the seed and seedling after planting.
- Insecticides are sometimes applied to protect seed in storage and in the soil.
- Treatments may be applied to protect the seedlings or adult plants against pathogens carried on or in the seed.

Dryer

- In humid and hot climates, seeds may be sealed in vapour- tight plastic bags to maintain viability over longerperiods.
- In such cases, wheat seed moisture content must be below 9 percent, preferably not over 8.5 percent. Usually, a dehumidified, closed-circuit dryer is used after the seed treatment is applied.

Bagger-weigher

- The final step is to weigh the proper amount of seed intothe proper kind of bag.
- Wheat seed bags should be of a size that fits local farmer needs (seed rates and field size).

Storage of wheat

- Seed should be harvested when it reaches harvest maturity, dried to a safe moisture content (if necessary), stored under favourable conditions and protected from damage and pests until it can be planted.
- Immature or damaged seed cannot survive long storage periods.
- Mechanical injury to seed during harvest or handling makes it more susceptible to deterioration in storage.
- seed should be properly dried before going into storage and protected from moisture and high relative humidity.
- Fungi *(Aspergillus* and *Penicillium)* cause damage to stored seed if seed moisture is high.
- High storage temperature has a damaging effect on seed. Stores should be designed so that low temperatures are maintained;
- In general, stored wheat seed should be kept at moisture content levels below 12 percent and relative humidity should not exceed 50 to 60 percent. The cleaned, bagged seed should be stored in a dry, insect and rodent proof warehouse.
- Effective rodent control (traps and poison) is essential in all seed stores.
- A complete programme of exclusion ,
- sanitation and control should be used;

Insects should be controlled by a combination of insecticides and fumigants. Use safest fumigants (e.g. Phostoxin) because some fumigants (e.g. methyl bromide

Assignments: Visit to Wheat processing plant and take a observations and write in this exercise.

Exercise No. 19

Summary report of practical crop production - II

Objects: - To know the procedure of writing of summary report of a given experimental crops.

Each student should write a summary report of Agronomical field work done in wheat crop in course No. 248 on the following points.

1. **Soil** of a given plot.

2. Climatic conditions: - Season report of *rabi* on various climatalogical parameters like temperature, humidity rainfall, rainy days distribution pattern of rainfall (Appendix I). The student should also compare *rabi* season with last 10 years data of various climatic parameters.

3. Effect of weather on wheat crop: - Mention the effect of various climatic parameters on germination, growth and yield of Wheat crop.

4. **Constrains** experienced while doing the various operations Management, availability of various inputs in raising the Wheat crop & suggest ways to over come the constraints.

5. **Profit of Wheat crop: -** Give logical reasons for profit or loss.

Assignments: - Write in detail summery report of wheat crop which you have studied in this course.(Attach separate page if needed)

-Study of weekly weather record for Rabi season.

Weekly weather record for Mean maximum and minimum temperature, Rainfall, number of rainy days and humidity during Year ………………. At College of Agril. ………………

Month	Met Week No.	Temperature ^{0}C		Rainfall (mm)	Humidity %	
		Max.	Min.		Morning (0730 hrs)	Evening (1430 hrs)

..‘

INDEX

Practical Crop Production - II (Rabi Crops) Credit - 0 + 1

Ex. No.	Title of the Exercise	Page No.	Date	Sign.	Remarks
1.	Introduction, aims and objectives of practical crop production - II, allotment of plot and its history.				
2.	Study of seed production of rabi crops				
3.	Study of mechanization and Resource conservation in rabi crops				
4.	Study of physical and chemical properties of the allotted plot to the students.				
5.	Study of package of practices for growing Wheat crop (timely, late and rainfed)				
6.	Preparation of calendar of operation for Wheat.				
7.	Study of preparatory, secondary tillage and seed bed preparation for Wheat.				
8.	Sowing and seed treatment of Wheat.				
9.	Study of integrated nutrient management of Wheat.				
10.	Study of water management to Wheat.				
11.	Determination of germination/emergence count of Wheat				
12.	Study of growth and yield contributing attributes in Wheat.				
13.	Study of interculturing and weed management in Wheat.				
14.	Study of integrated insect pest and diseases management in Wheat.				
15.	Study of crop maturity signs, harvesting of wheat				
16.	Threshing, drying, winnowing, storage and preparation of produce for marketing of Wheat.				
17.	Study of cost of cultivation and working out net returns per student.				
18.	Study of post harvest technology of wheat				
19.	Summary report of Practical Crop Production - II				
20.	Study of weekly weather record for *Rabi* season.				

Certificate

This is to certify that Shri./Ku. ____

Enroll. No. ______________has completed practical of Course No. Agro – 3611 (N) (Practical Crop Production - II (Rabi Crops) as per the syllabus of B. Sc. Agri. (Hons.) second year fourth semester in the laboratory of College as prescribed by M. C. A. E. R., Pune

Date:- Course Teacher

Practical Manual
AGS- 609
Farm Management, Production and Resource Economics

Contents

Ex. No	Date	Title of the Exercise	Date of Submission	Signature & Remarks
1		Preparation of Farm Layout and Estimation of Cost of Fencing of a farm		
2		Computation of depreciation and cost of farm assets: Valuation of assets by different methods		
3		Application of equi - marginal returns / opportunity cost principle in allocation of farm resources		
4		Determination of most profitable level of inputs use in a farm production process		
5		Determination of Least-Cost Combination (LCC) of inputs		
6		Selection of most profitable enterprise combination		
7		Application of cost principles including CACP concepts in the estimation of cost of cultivation and cost of production of agricultural crops.		
8		Estimation of cost of cultivation and cost of production of perennial crops / horticultural crops		
9		Estimation of cost and returns of livestock products.		
10		Preparation of Farm Plan and Budget		
11		Farm Records and Accounts: Usefulness, types of farm records– farm production records-farm financial records		
12		Preparation of Cash Flow Statement		
13		Preparation and Analysis of Net worth Statement and Profit and Loss statement		
14		Estimation of Break – even analysis.		
15		Graphical solution to Linear Programming problem		
16		Collection and analysis of data on various resources in India		

Ex. No.: 01 Date:	**Preparation of Farm Layout and Estimation of Cost of Fencing of a Farm**

Farm layout means the physical arrangement of fields and other permanent structures such as buildings, roads, channels etc. Farm layout has direct relationship with cost and efficiency in use of machineries, man power, animal power, irrigation and drainage and in turn affects the profit. Hence, there is a need for good farm layout. Good farm layout should ensure;

1. Optimum size of fields to suit the cropping pattern.
2. Minimum area under buildings, roads and irrigation channels.
3. Easy access to all fields and buildings.
4. Uniformity of soil in each field or within a block.
5. Efficient and economic irrigation structures.

An efficient layout is one which fits well with the enterprise and crop rotation leading to the saving of time, energy and money and efficient operation of the farm business.

Points to be considered for farm layout

1. Topography of the land

While dividing the whole area into different segments (or) fields, adequate care should be taken such that lands with uniform level are brought under a single category (or) block. On a sloppy land, the layout should be planned with the object of checking (or) reducing soil erosion and water run-off.

2. *Location, size and shape of the field*

The fields with uniform soil type should be brought under major block. If there is any problem soil like saline, alkaline, low fertility, prior identification would facilitate the problem soil under single block. This would help in adoption of suitable reclamation.

The location of cultivable plots should allow an easy accessibility and movement of farm produces in farm and movement of farm operators. Depending upon the availability of land, extent of mechanization, soil type and fertility, irrigation facilities, size and shape of the fields vary. However, it is always desirable to have small number of large sized fields, to achieve maximum utilization. *As* far as possible the field should be uniform in size with rectangular shape.

3. *Purpose of farming*

Before any farm layout is designed, the decision-maker should clearly define the purpose for which farming is carried out. It may be for research (or) commercial farm/ orchards/seed multiplication plots/demonstration plots etc.

4. *Type of enterprises*

An enterprise may be specialized (or) diversified, single (or) mixed enterprise etc. If mixed enterprise is planned, a layout should have a provision to accommodate the necessary infrastructural facilities like farm buildings, grazing lands etc.

5. *Sources of Irrigation*

The irrigation source may be surface (or) ground water. While designing farm layout and construction of irrigation structures, the water supply and its potential has to be assessed. Such assessment would help in defining the cropping pattern and classifying the land as irrigated, dry etc. Besides, one should also consider the slope of the land, topography and soil type for better irrigation, coverage and efficient distribution of water. The water flow should be in accordance with the land gradient and thus the plan layout will have an efficient irrigation and drainage network with minimum conveyance loss.

6. *Buildings and Roads*

To facilitate easy accessibility of different fields and to monitor (or) supervise the day-today functions, it is always desirable to have the farm buildings at the center. It is better to locate storage go downs and implement sheds adjacent to farm office to control pilferage. The approach road should be wider i.e.., 15-20 ft and link roads should be 9-10 ft width. Adequate care should be taken to minimize the area under buildings and roads and other permanent structures.

8. *Cropping Pattern*

Farm income is greatly influenced by cropping pattern. The cropping pattern varies from farm to farm depending upon soil type and fertility, water availability and other socio-economic factors like preference of decision maker, market availability, price etc. In designing farm layout, area allocation for perennial crops should be planned well ahead since the crop may occupy the land permanently.

9. *Transport and Communication*

For efficient transit of farm produce soon after harvest, required transport and communication facilities may be created in the farm.

10. *Fencing*

This is essential to fix the boundary of the farm and to protect the farm from trespassing and encroachment. Fencing is an age-old practice and it is all about privacy, beauty and security that a farm demands to offer best out of its all. Fencing is a one-time investment and affords a long-term protection for agricultural fields and properties and helps curtail crop losses from diverse disruptive causes.

An effective fencing set up can

1. Demark a possessed property (legal requirement),
2. Keep out stray animals and intruders,
3. Separate lands in case of mixed farming,
4. Keep trespassers away,
5. Protect land and crop, and many more.

Types of fencing offer various cost effective and environmentally friendly fencing solutions.

1. Wooden fencing,
2. Live fencing
3. Stock fencing,
4. Wire fencing,
5. Synthetic fencing,
6. Rail fencing, and
7. Power fencing
8. Solar fencing

Living Fence: Living fence around the farm has multiple benefits. Besides protection from trespassers and cattle, a living fence also provides a buffer, and with a sensible choice of plants, evens some cash crops. Live fences can be divided into two basic categories:

a) ***Live fence posts:***

Live fence posts are widely spaced, single lines of woody plants that are regularly pruned back and used instead of metal or wooden posts for supporting barbed wire, bamboo or other materials.

b) ***Live barriers or hedges***

Hedges are thicker, more densely spaced live fences that generally include a number of different species and do not normally support other fencing material.

The species suitable for live fence should be thorny, non-edible and non-browsable for cattle and goats, hardy and relatively maintenance-free (other than pruning / lopping), adaptable to the local conditions, fast-growing and producing something that can yield some revenue.

The primary purpose of live fences is to control the movement of animals and people; however, they have proven to be extremely diverse, low risk systems that provide farmers with numerous benefits. Besides their main function living fences can provide fuel wood, fodder and food, act as wind breaks or enrich the soil, depending on the species used.

A live fence should ideally be planted just before the monsoons and watered regularly after the rainy season is over to ensure optimum growth. Usually thorny plants are grown to make a live fence. For example bushes such as agave and cactus, creepers, and small shrubs (perennial bushes) are the most sought after ones. Besides, trees such as Subabul and Gliricidia can also be planted as live fence.Often trees in living fences are allowed to grow to larger sizes than with hedges. A genus of particular importance as living fence is Gliricidia which can serve both as fences and as sources of fuel wood and fodder.

Agave crop comes up on dry soils unsuitable for crop cultivation but grow vigorously on dry, well drained sandy loam soils. In the border, a trench with a width of 30 cms may be dug and the soil excavated should be used to make raised bed at the inner side of trench. The agave saplings are planted during the rainy season at a space of 45 Cms in pits of 20 cm^3.

Gliricidia sepium is a common live fence post species established through large stem cuttings root with relative ease, and it has multiple uses such as a forage and green manure. Combination of Agave, Sisal and Gliricidia is suggested as live fence. The cost of live fence is very minimal @Rs 7- 8 per running feet. A perimeter of 3000 ft. (10 Acres) would cost around Rs. 25,000 as against other alternatives.

Farm wired fencing costing Rs 50 to Rs 120 per running feet. Particularly for Barbed wire, Electric/ invisible, woven wire, hog wire and Hog panel, Deer and mesh & chicken wire are suitable for farm based on the requirement.

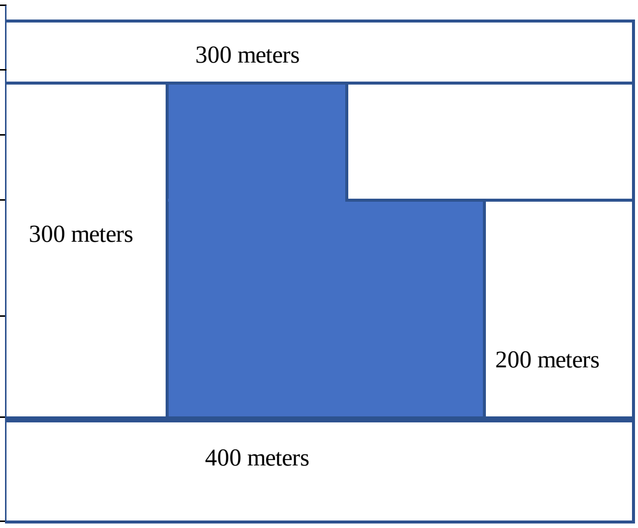
Type of fence	Materials	Rs /feet
Security style wire fence	Wire mesh, chain link and metal option	100-250

Problem 1: Estimate the cost of fencing for 10-hectare farm of the given layout. Use barbed wire type fencing for 6 feet height of which 3 feet for 15 cm x 30 cm gap at bottom and 30cm x30cm gap for remaining upper 3 feet height. Use supporting stone post at every 7 feet on the cost of Rs 150 per post. In order to give strength to the structure, provide two side supporting post at every 100 feet. Total height of the stone post is 7 feet of which erect them at one feet depth with concrete support, costing Rs 20 per pit for including labour and material. The barbed wire costing Rs 8000 per quintal running to the length of 3000 feets. An average amount of Rs 30 per feet is required as labour cost for fencing. (Hint: Estimate the barbed wire cost per 10’ x 6’ and estimate the total material (stone post and barbed wire) costs. Layout of the farm is given below;

Material and Labour cost

S.No	Details	Unit	Rs
1	7’ Stone post	1 No	150
2	Barbed wire	qtl	8000
3	Pit making and filling with concrete	Per pit	20
4	Fence commissioning cost	Per 10’ fence	30
5	Other material expenses	10’ fence	5

10 Hectare Farms



Ex. No.: 02 Date:	**Computation of Depreciation and cost of Farm Assets: Valuation of Assets by Different Methods**

A. *Depreciation*

While estimating cost or expenditure incurred, there is no problem in accounting for the cost of mono period resources. The difficulty arises in accounting for the cost of poly period resources, as they provide services for a number of years to the farm business. Farmer uses different resources during the production period of an agricultural year. It is not rational to account for the entire purchase price of these resources as a cost in a single production cycle, since they are used in many production cycles. Depreciation is such an accounting procedure to account for the cost of services rendered by the poly period resources in each production cycle in which they are used. It is also known as capital consumption allowance.

Depreciation involves spreading of the original cost of an asset over its entire useful life. Depreciation is an non-cash expenses that reduces the exact value of an asset over time due to its wear and tear of its use. The loss in value of an asset over time is determined by the following factors: (i) Remaining life; (ii) Extent and nature of use (iii) Time obsolescence

The relative importance of the above factors varies with the kind of asset and the use to which it is put. Depreciation charges may either be spread uniformly over the entire useful life of an asset or they can be relatively heavier during the early life of an asset, depending on the nature and extent of use of the asset. Thus, some methods of calculating depreciation may be more appropriate for some assets than for others. Three common methods of calculating depreciation are discussed below:

1. *The straight - line method*

By this method, the annual depreciation of an asset is computed by dividing the original cost of the asset less salvage value by the expected years of life, i.e., $AD = \frac{OC-SV}{EL}$

Where AD, OC, SV and EL stands for annual depreciation, original cost, salvage value and expected life period in years respectively. Annual depreciation remains the same for each year during the useful life of the asset.

Example: What would the annual depreciation for an asset be whose cost is Rs. 1,000, salvage value Rs.100 and expected useful life 10 years?

$$Annual\ Depreciation = \frac{1000-100}{10} = \frac{900}{10} = Rs\ 90\ per\ year$$

This method is relatively simple and easy to understand even by semi-literate farmers.

However, equal loss in value every year during the entire expected useful life of an asset may sometimes be too unrealistic. This method is useful for durable assets like buildings and fences which may require uniform maintenance during their lifetimes.

2. ***The Declining- Balance method***

According to this method, a fixed rate of depreciation is used every year and applied to the remaining value of the asset at the beginning of each year. It is important to note that salvage value is not subtracted from the original cost as in the previous method. Instead, a fixed rate of depreciation which should be nearly twice that used under the straight line method is applied to the uncovered balance until the salvage value is reached, after that no depreciation is worked out.

DDB = (C - A) x R

DDB = Depreciation / year by declining balance method

C = Purchase Cost

A = Accumulated depreciation taken in prior years

R = Rate at which depreciation is taken (usually twice the straight line method)

This is useful in a situation, where an asset depreciates at a faster rate in the beginning as in the case with most machinery and the automobiles.

Example: Assume, Rs. 1,200 as value of an asset with an expected life of 10 years and a salvage value of Rs. 200. The rate of depreciation is 20 percent.

Calculations of depreciation by using the Declining - Balance method

Year	**Value at the beginning of the year (Rs.)**	**Annual depreciation (Rs.)**	**Remaining balance (Rs.)**
1	1,200	1200 × .2 =240	1200 - 240 = 960
2	960	960 × .2 = 192	960 - 192 = 768
3	768	768 × .2 = 153.6	768 - 153.6 = 614.4
4	614.4	614.4 × .2 = 122.88	614.4 - 122.88 = 491.52

After the fourth year, the same procedure is continued till the remaining balance reduces to an amount equal to the salvage value, i.e., Rs. 200 in this case.

This method is suitable for a situation where an asset depreciates at a faster rate in the beginning as in the case with most machinery and automobiles.

3. ***The sum- of - the -year Digits method***

The following formula is used for calculating the annual depreciation (AD) by this method:

AD = F × Amount to be depreciated,

Where amount to be depreciated equals the cost less salvage value and F is a fraction. F for any year, say the second year, for an asset with an expected life of five years can be calculated as follows:

F = <u>Years of remaining life at the beginning of accounting period</u>

Sum-of-the-year-digits

$$F = \frac{4}{1+2+3+4+5} = \frac{4}{15}$$

Similarly, F for first and fifth year will be $\frac{5}{15}$ and $\frac{1}{15}$ respectively. As the value of F keeps on declining each year, the annual depreciation also declines with the advancement in age of the asset as in the declining balance method. This method also suits those assets for which relatively higher depreciation needs to be charged during the earlier years of their life.

Value at the beginning of the year	**Annual depreciation (Rs.)**	**Remaining balance (Rs.)**
Year 1 Rs. 1,200	$\frac{10}{55}$ (1,200 - 100) = 200	1,200 -200 = 1,000
Year 2 Rs. 1,000	$\frac{9}{55}$ (1,200 - 100) = 180	1,000 -180 = 820
Year 3 Rs. 820	$\frac{8}{55}$ (1,200 - 100) = 160	820 -160 = 660
Year 10 Rs. 120	$\frac{1}{55}$ (1,200 -100) = 20	120 -20 = 100

This method is perhaps much more complicated than the straight - line method and thus not as popular.

Problem 1: Work out the depreciation values three methods such as straight-line method, the declining- balance method and the sum- of - the -year digits method for a power sprayer (purchased in 2008) and a tractor (purchased in 2004). The power sprayer was purchased for Rs 10000 (salvage Rs 100) and the tractor was purchased at Rs 2.5 lakhs (salvage 10 % cost). Use 20% depreciation rate for power sprayer and 10% depreciation for tractor for calculating Declining balance method. Calculate the depreciation by all three method and offer your comments.

Problem 2: Calculate depreciation for the power tiller purchased for Rs.1, 50,000 by the above three methods. The salvage value is Rs.15,000, depreciation percentage is 12% per year and its economic life is 12 years. Offer your comments.

Problem 3: Calculate depreciation value (by any two methods) of an oil engine purchased at Rs.12, 000 with an expected life of 10 years and salvage value of Rs.1, 200.

B. ***Valuation of farm assets***

Farm inventory is a complete listing of all that a farm owes at a particular date generally at the beginning and the end each agricultural year. It includes not only the listing of physical assets but values of all such assets, liabilities and debts as well. There are two steps involved in taking a farm inventory.

1. ***Examination of physical Assets***

It includes a complete listing of all the physical assets, including a verification of weights and measures. The losses, wastages, shrinkages or gains which accrue over time are all accounted for.

2. ***Valuation physical assets***

After the physical assets have been examined and listed, it is important to value them. Valuation of farm inventories is an important step in the process of taking an inventory on a farm. The nature and purpose of an asset generally determines the best method for its valuation. However, a few common methods of valuation are discussed below:

Valuation at Cost: According to this method, the amount of money actually invested on the assets when it was acquired is entered in the inventory. This method has the following limitations:

(i) It cannot be used for the valuation of farm products.
(ii) The effects of inflation and deflation are ignored.
(iii) Original investment value has only a limited use when considered somewhere in the middle of the business.

Net Selling Price: The method of valuation is generally applied to those assets which are primarily held for sale on the farm. It represents market price less the selling costs. It is an effective method of valuation for crops and livestock produced for the market. However, it cannot be used for the valuation of buildings and machines for which no actual market may exist.

Cost minus Depreciation: The method assumes that the p9urchase price of an assets approximates its value. Thus, the value of the assets in subsequent years can be estimated by subtracting the depreciation from its cost. This is a popular method for the valuation of machinery and breeding livestock.

Cost or Market Price, whichever is less: In general, market price provides the best approximation of its value. Farm supplies are generally valued using this method but it can understate or overstate the value of an asset.

Replacement Cost: It represents a value of an asset which is equal to the cost to reproduce the asset at the present prices and under the existing technological improvements. This method may be successfully employed for the valuation of fixed and long-lived asset.

Replacement Cost Less Depreciation: It represent an improvement over the previous method as it provides a more realistic valuation of fixed and long-lived assets like buildings, particularly when wide price changes may occur. However, this method should be used very carefully as it may often lead to over valuation.

Income Capitalization: For assets like land whose contribution towards the income can be measured for each production period and have long life, income capitalization is an ideal method of valuation. The expected level of income is Rs.1000 per year, the present value of the land then can be easily assessed by using this method, if the rate of interest is 10 per annum, i.e.,

$$Present\ Value\ (PC) = \frac{Per\ year\ return\ (R)}{Interest\ rate\ per\ annum\ (r)} = \frac{1000}{0.10} = Rs\ 10{,}000$$

Thus, price of land in question would be valued at Rs.10,000. This method is generally used in combination with other method.

In short,

(i) For all assets that will be sold within the year, use the net selling price.

(ii) For all farm supplies (inputs) use cost or market price whichever is lower.

(iii) For capital asset which includes machinery and breeding livestock, cost less depreciation is the best method of valuation.

(iv) For farm buildings, if constructed a long time ago, use the replacement less depreciation method, For other building, constructed only a few years ago use the cost less depreciation method.

(v) For farm land, use the Income capitalization method to obtain its present value.

Ex. No.: 03 Date:	**Application of Equi-Marginal Returns / Opportunity Cost Principle in Allocation of Farm Resources**

Cultivator has limited capital and his main objective is to maximise net profit. Farmer is having several alternatives for his available capital. He should spend the amount, in such a way that he will get maximum profit. This can be achieved by using the principle of **equi-marginal returns**. The equi-marginal return principle helps us to understand how to achieve maximum return by allocating the available capital to the different enterprises.

The law of equi-marginal return states that "the profits are maximized by using the resource in such a way that the marginal returns from the resources are equal in all cases."

Farmers reach maximum return when he allocates every additional amount of capital so as to get equal marginal return. Thus, the producer will be in equilibrium when the following equation holds good:

$$\frac{MRx}{Cx} = \frac{MRy}{Cy} = \frac{MRz}{Cz} = MR\mathrm{m}$$

Where MR = marginal return in each enterprise and C is cost/investment in each enterprise.

This principle can be illustrated with the help of following example. Suppose, farmer is having Rs.50,000 for investing. His locality is favourable to take crop enterprise, dairy enterprise and poultry enterprise. It is observed from the table that, when all the amount was invested in any one enterprise net profit from crop enterprise, dairy enterprise and poultry enterprise is obtained as Rs. 26,000, Rs.22,000, and Rs. 28,000 respectively.

S.No.	Investment pattern (Rs)	Return realized per Rs 10000		
		Crop	Dairy	Poultry
1	First 10000	20000	19000	21000
2	Second 10000	19000	18000	19000
3	Third 10000	15000	15000	15000
4	Fourth 10000	12000	11000	12000
5	Fifth 10000	10000	9000	11000
	Total realized return	76000	72000	78000
	Total amount invested	50000	50000	50000
	Profit in each enterprise	26000	22000	28000

However, if the same amount is spent according to principle of **equi-marginal returns**, total net profit will be as shown below in the table given below.

Expenditure according to principle of equi-marginal return

Order of investment	Amount	Enterprise	Marginal Return
First	10000	Poultry	21000
Second	10000	Crop	20000
Third	10000	Crop	19000
Fourth	10000	Dairy	19000
Fifth	10000	Poultry	19000
Total	50,000		98000
Net Profit			48000

It is observed from the above table that cultivator is getting total net profit of Rs. 48000 which is more than profit from any single enterprise. Thus, for maximum net profit cultivator should invest Rs.20000 in crop enterprise, Rs.20000 in poultry enterprise and Rs. 10000 in dairy enterprise. It is observed from the above table that marginal returns from all the three enterprises are equal i.e. Rs.19000. Thus, it can be stated that amount should be invested in such a way that marginal returns should be equal in all the alternatives.

Opportunity cost

In agriculture, resources are limited and have alternative uses. When resource is put to one use opportunities of other alternatives are lost. John A. Perrow defined "opportunity cost is the amount of the next best produce that must be given up (using the same resources) in order to produce a commodity." The concept was first developed by an Austrian economist, Wieser.

Opportunity cost are calculated by two methods:

(a) On gross income basis-when cost of production are equal.

Enterprises	**Gross income**	**Cost of production**	**Net income**
Tobacco yield 12 qtl @ Rs 3000/qtl	36000	10000	26000
Potato yield 140qtls @ Rs400/qtl	56000	10000	46000
In this case, it is better to grow potatoes than tobacco. The opportunity cost of growing tobacco is the gross income of Rs.56000 which was sacrificed by not producing potato.			

(b) On net income basis-when cost of production are not equal.

Income	**Tobacco**	**Potato**	**Wheat (HYV)**
Gross income	36000	56000	70000
Cost of production	10000	10000	18000
Net income	26000	46000	52000
In this case net income generated by the three crops, tobacco, potato ad wheat are Rs 26, 46 and 52 thousand respectively. It is therefore, wise to grow wheat at it gives the highest net income. The Opportunity cost of growing potato is the net income of Rs. 52000 which was sacrificed by not growing wheat			

Opportunity cost is the return, the resource can earn when it is put into its next best alternative use.

Ex. No.: 04 Date:	**Determination of most Profitable Level of Inputs use in a Farm Production Process (How much to produce)**

A factor product relationship is considered as one of the basic relationships in production economics which helps to identify the optimum level of input to produce the output which give maximum profit. In the short run, this analysis explained the law of diminishing marginal returns or law of variable proportion. Actually, this refers to the study of output or return in situations where the proportion of inputs (variable inputs to fixed inputs) are varied, hence this principle is called as **law of variable proportion**.

Definition

Law of Diminishing Returns or Law of Variable Proportions

It states that if one variable factor is increased with quantities of other factors held constant, the marginal increase to the total product may increase or remain constant at first but will eventually decrease after a certain point.

If successive units of one input are added to given quantity of other inputs, a point is reached, where the addition to product per additional unit of input will decline. This principle establishes the technical relationship between the inputs and outputs known as production function. A production function is a mathematical relationship explaining the way in which the quantity of a given product depends on the quantities of different inputs which are employed in the production process.

A production function shows the relationship between the output of an enterprise and variable inputs needed to achieve the output. It can be expressed in verbal, graphical and mathematical form.

A production function can be specified as

$$Y = f\,(X_{1/}, X_2, X_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots X_n)$$

(Output of teak in cubic meter per hectare is the function of fertilizers, seeds, manures… etc.) Here the inputs which are variables in the process of production are placed on left hand side of the bar and the inputs which are held constant are written on the right hand side. This law clearly indicates the total, average and marginal products curves for single variable input with the combination of other fixed inputs.

Total Physical Product (TPP)

It represents the total output or yield that can be attained with the variable input X_1 and a set of fixed inputs X_2 …… X_n.

$$Y = f(X_1 / X_2, X_3 \ldots\ldots\ldots\ldots\ldots X_n)$$

Average Physical Product (APP)

It is the total physical product due to the variable input. ie., it is the total output divided by the number units of the variable input. APP$=\frac{Y}{X}$; where Y = Total physical product and X = Input level

Marginal Physical Product (MPP)

It shows the change of total product associated with using each additional unit of variable input (X)

$$MPP = \frac{\Delta Y}{\Delta X}$$

Elasticity of Production: It is the ratio between the per centage change in output and percentage change in the input level. The elasticity of production can also be defined in terms of relationship between MPP and APP as given below.

$Ep = \frac{\frac{\Delta Y}{Y}}{\frac{\Delta X}{X}} = \frac{\Delta Y}{\Delta X}\ x\ \frac{X}{Y}$ We know that $\frac{\Delta Y}{\Delta X}$=MPP and that $\frac{Y}{X}$=APP; Therefore Ep=$\frac{MPP}{APP}$

Different Stages of Production

Stage I (Irrational Zone)

1. TPP is increasing at increasing rate
2. MPP is increasing
3. APP is increasing
4. Ep ≥ 1
5. Stage ends where MPP = APP

Stage II (Rational Zone)

1. TPP is increasing at decreasing rate
2. MPP is decreasing
3. APP is decreasing
4. 0 < Ep < 1
5. Stage ends where MPP = 0

Stage III (Irrational Zone)

1. TPP is decreasing at increasing rate
2. MPP is negative
3. APP is decreasing
4. Ep < 1

Relationship between MPP and TPP

1. When MPP is increasing, TPP is increasing at increasing rate.
2. When MPP is > zero and decreasing, TPP is increasing at decreasing rate.
3. When MPP is zero, TPP is at its maximum.
4. When MPP is negative, TPP is decreasing.

Relationship between MPP and APP

1. When MPP > APP, APP is increasing.
2. When MPP = APP, APP is maximum.
3. When MPP < APP, APP is decreasing.

Optimum Output production

There are two optimum in the production process.

1. Physical optimum/ agronomic optimum level of production by applying variable input up to MPP=0.

2. The economic optimal level of input use can be found out by equating the Marginal Value Product (MVP) and the Marginal Cost of input use (MC): **MVP = MCx**

MVP = MPPx x Py

MCx = P x

Ex. No. : 05 **Date:**	**Determination of Least-Cost Combination (LCC) Of Inputs**

Farmers often use inputs, which are substitutable - with one input (say X_1) for the other (say X_2) - to produce a given level of output. In such situations, a farmer may be interested to know which combination of these inputs cost him the least. This particular combination is known as least cost combination.

Optimum combination of two inputs (X_1 and X_2)

When different combinations of two inputs are available for producing a given amount of output, a farmer has to select the optimum combination among the various combinations. The optimum combination is one which results in least cost (minimum cost) for producing a given amount of output. The least cost principle says that a producer can add more and more units of one input (**X_2**) to replace another input (**X_1**) as long as the value of the replaced input ($- \Delta$ **X_1**.P_{X1}) is greater than the value of the added input (Δ C.Pc. > Δ L.Pl). **The optimum or Least Cost Combination (LCC) is obtained when MRTS $_{X1\,X2}$ = inverse price ratio between X_2 and X_1**

Marginal Rate of Technical Substitution (MRTS)

It refers to the number of units of an input that must be reduced for one unit increase in another input to maintain the given level of output.

$$\text{MRTS } X_2X_1 = \frac{\textit{units of replaced input } X_1}{\textit{units of added input } X_2} = \frac{\Delta X_1}{\Delta X_2}$$

Least Cost Combination

A given level of output can be produced using many different combinations of two variable inputs. Here the problem is to find out a combination of inputs, which should cost the least, and result in better returns to the farmer. There are three methods to find the least cost combination (LCC).

1. ***Tabular or Arithmetic method***

One possible way to determine the least cost combination is to compute the cost of all possible combinations and then select the one with minimum cost. The method is suitable where, only a few combinations produce a given output.

2. ***Algebraic Method***

The LCC is at a point where the slope of the isoquant is equal slope of the iso cost line. The slope of the isoquant is called marginal rate of technical substitution (MRTS).

1. Compute Marginal rate of Technical substitution (MRTS) of X2 for X1 MRTS $X_2X_1 = \frac{\Delta X_1}{\Delta X_2}$
2. Compute slope of the price line/ iso cost line is inverse price ratio of input

$$\frac{\Delta X_1}{\Delta X_2} = \frac{PX_2}{PX_1}$$

So, the least cost combination (LCC) is MRTS=slope of budget line which is **inverse price ratio.**
If these ratios are cross multiplied, then the relationship will be A X_2.P X_2 = -A X_1.P X_1. Hence, as long as MRTS is greater than the price ratio, X_1 can be replaced by adding more X_2. Graphically, it is the point at which the **budget line (Iso-cost line) is tangent to the isoquant**, (Fig.). The least cost combination can also be found out by computing the total cost for each combination and selecting the particular combination which results in minimum cost.

Iso cost line can be derived by solving TVC.

$$TVC = PX_1X_1 + PX_2X_2$$

$$PX_1X_1 = TVC - PX_2X_2$$

$$X_1 = \frac{TVC}{PX_1} + \frac{PX_2}{PX_1}X_2$$

$$X_1 = a - bX_2$$

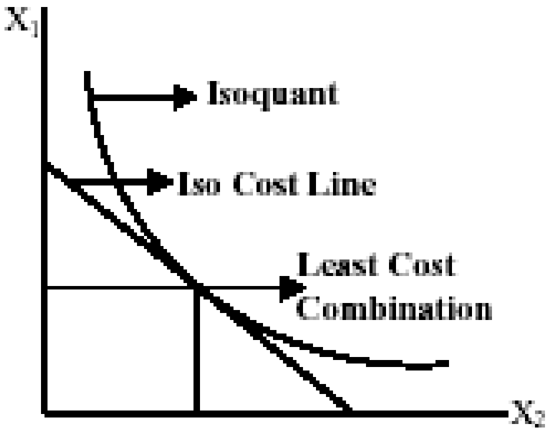


Fig : Least cost combination of Factors

3. **In graphical method:** using the value calculated in algebraic method the isoquant and budget line are drawn in a graph sheet. Suitably moving the budget line without changing the slope, the tangency to the isoquant gives the least cost combination of inputs.

Problem 1: The following N and P fertilizers combination produce 2100 kg of Dry Chillies per ac. The cost of nitrogen is Rs 34 and Phosphorus is Rs 42.5. Find out the least cost combination also draw the graph of iso-quant and iso-cost curves.

Nitrogen (X1)	**Phosphorus (X2)**	**ΔX1**	**ΔX2**	**MRS=** $\frac{\Delta X_1}{\Delta X_2}$	**Price** ratio= $\frac{PX_2}{PX_1}$	**Total Cost (Px1.X1+ Px2.X2**
65	40					
70	25					
75	17					
80	11					
85	7					
90	4					
95	2					
100	0					

Problem 2: Different combinations of two animal feeds, Lucerne -X_1 and Concentrate-X_2 required to produce 2000 liters of milk in 280 days are given in the following table. (column to be followed

$X1, X2, \Delta X1, \Delta X2, MRTS = \frac{\Delta X_1}{\Delta X_2}, \frac{PX_2}{PX_1}, TVC = PX_1X_1 + PX_2X_2$)

(1) If the price of X_1= Rs.0.6 and price of X_2 = Rs 6.3 find out the least cost combination.

(2) Estimate LCC if P_{X1}=Rs 0.30 and P_{X2}= Rs 2.1

(3) Plot the iso- quant and iso- cost curve in a graph.

X_1	6500	6680	6890	7140	7440	7790	8200	8685	9255	9915
X_2	1050	1000	950	900	850	800	750	700	650	600

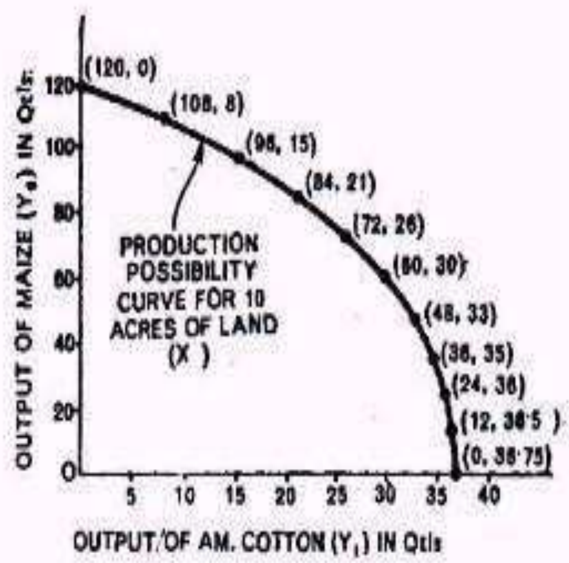
Ex. No.: 06 Date:	**Selection of Most Profitable Enterprise Combination**

The aim of the study of product – product relationship is to determine the optimum combination of products for a given level of input. Here, products refer to different enterprises like crops, dairy, poultry, etc. which can be produced from the same inputs.

Production Possibility Curve (PPC/ Iso Resource curve

The production possibility curve presents all possible combinations of two products that could be produced with given amounts of input.

Production possibility curves are sometimes called opportunity curves or iso - resource curves. Term '*opportunity curve'* is used because the curve presents all possible production opportunities. It is known as iso - resource curve because each output combination on this curve has the same resource requirements. Production possibility curve can be drawn either directly from production function or from total cost curve. The production possibility curve in figure thus presents all possible combinations of two products (cotton and Maize), with 10 units of input (10 acres of land).



Production possibility curve for two competing products substituting at increasing rate.

Unlimited resource availability situation

When the amount of available input is unlimited, resource allocation is determined by equating the price of input to Marginal Value Product of output.

Px = MVP (MVP = MPPx x Py)

Limited resource availability situation

The inputs are to be shared judiciously among different enterprises when the inputs are limited in quantity. The degree of interdependence among enterprises depends on their technical and economic relationships.

Competitive Products

Products are termed competitive when output of one product can be increased, only by reducing the output of the other product. Outputs are competitive because they require the same input at the same time. e.g. production of sugarcane and paddy under irrigated condition, when they compete for water.

Complementary products

Two products are complementary if an increase in the production one product causes an increase in the production of the second product, when the total amount of input used on the two are held constant. e.g. If cereals are grown after a pulse crop, the output of cereals increase because the legume crop fixes atmospheric nitrogen and makes it available to the succeeding cereal crop.

Supplementary Products

Two products are called supplementary if the production of one of the products can be increased without increasing or decreasing the production of the other product. e.g. sunflower cultivation and honey bee rearing.

Joint Products

The products which results from the same production process are termed joint products. e.g. Wool and mutton, paddy and straw.

The optimum product combination is the one, which maximizes the profit. It is obtained when the **substitution ratio** of the products (MRPS –Marginal Rate of Product Substitution) equals the inverse **price ratio**.

Determination of Optimum Product Combination

For profit maximization, a rational producer should operate in the range where two products are competitive and within this range, the choice of products would depend upon the marginal rate of product substitution and output price ratio.

1. Algebraic Method

Work out the marginal rate of product substitution of sorghum $y1$ for bajra $y2$ (Signs ignored)

1. Compute Marginal rate of Product Substitution of $Y2$ for $Y1$: MRPSY_1Y_2)

$$\text{MRPS } Y_2Y_1 = \frac{units\ of\ replaced\ output\ Y_1}{units\ of\ added\ output\ Y_2} = \frac{\Delta Y_1}{\Delta Y_2}$$

2. Compute inverse price ratio (PR) = $\frac{PY_2}{PY_1}$

3 Optimum products combination is obtained by equating MRPS=PR; $\frac{\Delta Y_1}{\Delta Y_2} = \frac{PY_2}{PY_1}$

Rule: If ΔY1.PY1 > ΔY2.PY2 more input should be diverted towards the production of Y_1, thus producing less of Y_2.

2. **Tabular method**: total revenue is calculated as $(Y_1.P_{Y1})+(Y_2.P_{Y2})$, and the combination with maximum total revenue is chosen as a best enterprise combination.

3. Graphic Method

The optimum combination of two products can be found out with the help of production possibility curve and iso-revenue line. The profit maximizing enterprise combination is identified where the iso-revenue line is tangent to production possibility curve.

Production possibility curve is drawn by joining all combination of two products to be produced for a given level of input. The **Iso-Revenue line** is drawn by joining the two extremes of level of outputs that yield the same revenue.

Problem 1: For the given problem, work out the optimum product combination. Let price of Cumbu (Y_1) Rs. 600/unit and Price of Bhendi (Y_2) Rs.1450/unit

Cumbu Y_1	Bhendi Y_2	ΔY_1	ΔY_2	MRPS= $\Delta Y_1/\Delta Y_2$	Price ratio Py_2/Py_1	Total Revenue $Y_1.Py_1+Y_2.Py_2$
120	0					
108	8					
96	15					
84	21					
72	26					
60	30					
48	33					
36	35					
24	36					
12	36.5					
0	36.75					

Comment on the revenue maximizing combination of the two products.

Problem 2: Choose the optimum combination of two enterprises, i.e. Bhendi and Chillies from the yield data given, if each one of these combinations can be produced by same level of input. The price of Bhendi is Rs. 21.5 per quintal and price of Chillies is Rs. 61 per quintal. Verify the results by working out the total revenue.

Bhendi-Y_1	2510	4330	5840	6920	7810	8340	8590	8765	8885
Chilles-Y_2	5810	5630	5380	5000	4425	4005	3700	3440	3220

Problem: 3. Combination of Tomato and Brinjal produced using 200kg of Nitrogen is given in the following table. Work out the optimum combination of Tomato and Brinjal for the given level of Nitrogen. (PY1 = Rs. 280 per quintal; P Y2 = Rs. 400 per quintal)

Tomato Y1 (qtl.)	Brinjal Y2 (qtl.)	ΔY_1	ΔY_2	MRPS	Price ratio Py_2/Py_1	Total Revenue $Y_1.Py_1+Y_2.Py_2$
0	60					
20	56					
40	50					
60	41					
80	30					
100	16					
120	0					

Ex. No.: 07 Date:	**Application of Cost Principles including CACP Concepts in the Estimation of Cost of Cultivation and Cost of Production of Agricultural Crops.**

Cost: Costs refer to the money value of effort extended or sacrifice made in producing an article or rendering a service or achieving a specific purpose. Costs thus are the expenses incurred in organizing and carrying out the production process. They include outlays of funds for inputs and services used in production. Money value of all inputs used in the production process is termed as the total cost.

Variable Cost: Variable cost is the cost that varies with the level of output. i.e., higher the level of output higher will be the variable cost and vice versa. These include expenditure on labour, bullock, machinery charges, seeds, manures, fertilizers, plant protection chemicals, irrigation charges, value of other miscellaneous inputs and interest on working capital.

Fixed Cost: Fixed cost is the costs that do not vary with the level of output. They have to be incurred whether cultivation has been done or not. It includes the value of services provided by the fixed inputs such as land revenue, taxes, rental value of land, depreciation on building and machinery and interest on fixed capital.

Cost of Cultivation: It refers to the cost of various inputs and input services used for raising a particular crop. It includes all the operations from land preparation to threshing, cleaning and taking the product from the field to home. Cost of cultivation always refers to unit area (acre or hectare).

Cost of Production refers to cost incurred in **production of one unit of output** and is normally associated with variable and fixed costs. The variable costs relate to the cost of variable inputs and fixed costs to fixed inputs. The components of variable costs in crop production are the value of seeds, manure, fertilizers, plant protection chemicals, wages for labor, hire charges for bullocks, machinery and the value of other miscellaneous inputs used in crop production. The interest on variable capital should also be worked out and included under variable cost. Fixed cost includes the value of services provided by the fixed inputs such as land, buildings and machinery. Rental value of land, interest on other fixed capital excluding land, depreciation, taxes etc., constitute the fixed cost.

Procedure for estimating the cost of production

1. Estimate the total variable cost of producing the crop in a given area.
2. Work out the total fixed cost for the farm and apportion it to the particular crop based on area and duration of the crop.
3. The sum of the total variable and fixed cost (item 1 and 2) gives the total cost of producing the output from the given area.
4. Divide the total cost (item 3) by the total output (in kg/qtl./tonne) to estimate the average cost of production/unit quantity.
5. If a by- product is also produced along with the main product (eg. paddy grains and straw), deduct the value of by-product (straw) from the total cost to get the net cost. The net cost is divided by the total quantity of the main product (grain) produced to get cost of production/unit output.
6. In the case of mixed crops, the total cost of producing crops in a given area can be apportioned among the crops based on the value of output obtained from each crop.
7. When inter crops are grown with main crop, the value of output from intercrops may be deducted from the total cost and the net cost can be worked out or the total cost may also be apportioned among the main crop and intercrop based on the value of output from each crop.

Estimation of the Cost of Cultivation using CACP concepts: **Cost of cultivation** on the other hand, relates to an accounting procedure of quantifying the **costs incurred in undertaking production per unit of land.** Cost of production i.e. cost of producing per unit of output helps as a benchmark of deciding upon the support prices, procurement prices fixed for particular production of crop outputs. Cost of cultivation on the other hand, is the benchmark for fixing the scale of finance for credit operations like crop loans etc.

In India, the Commission on Agricultural Costs and Prices (CACP) is involved in collecting farm level data and worked out cost of production. For easy computations, the commission categorizes the cost components as follows:

Cost Concepts

Cost A1: It includes all actual expenses in cash and kind incurred in production by the farmer.

1. Value of human labour (hired).
2. Value of bullock labour (both hired and owned).
3. Value of machine power (both hired and owned).
4. Value of seeds (both owned and purchased).
5. Value of insecticides and pesticides
6. Value of manure (both owned and purchased)

7. Value of fertilizers
8. Depreciation on farm implements and farm buildings.
9. Irrigation charges
10. Land revenue, cess and other taxes.
11. Interest on working capital.
12. Miscellaneous expenses (electricity charges, etc)

Cost A2 : Cost A1 + rent paid for leased in land

Cost B1: Cost A2 + Interest on value of owned capital assets (excluding land)

Cost B2 : Cost B1+ rental value of owned land

Cost C1 : Cost B1+ Imputed value of family labour

Cost C2 : Cost B2+ Imputed value of family labour

Cost C3 : Cost C2 + 10% of cost C2 (10% of cost C2 added to cost C2): This is a recently added concept to provide allowance for managerial functions undertaken by the farmer.

From the above classification certain cost components and various income measures are derived as follows:

Cost of production (per unit of produce) = (Cost C3- value of by product) / main product yield.

Income measures

1. Gross Income : Value of main product + Value of by product
2. Net Income : Gross return – Cost C3
3. Farm Business Income : Gross return – Cost A1
4. Owned Farm Business Income : Gross return – Cost A2
5. Family Labour Income : Gross return – Cost B2
6. Farm Investment Income : Net Income + Rental Value of Owned Land + Interest on Fixed Capital
7. Returns over Variable Cost : Gross Return – Variable Cost

Problem 1:

Using the given data, work out the different Cost concepts, Cost of Production and different income measures.

S.No	Particulars	Tomato Rs/ha	Onion Rs/ha
1.	Value of human labour	48735	33345
2.	Value of machine labour	7410	5870
3.	Seeds/planting material	9855	19834
4.	Manures and Fertilizers	26939	33803
5.	Plant Protection chemicals	8906	9740
6.	Irrigation expenses	750	850
7.	Yield (Ton/Ha)	24	10
8.	Land Revenue and other Taxes	550	425
9.	Interest on Working Capital (7%)		
10.	Depreciation of farm implements and buildings	3938	1765
11.	Rental Value of Owned Land	2500	1765
12.	Imputed value of family labour	3500	2000
13.	Interest on Fixed Capital other than Land	2357	1434
14.	Price / Kg (value of main product)	10	25
15.	Value of by product	2000	1500

Problem 2: A farmer cultivated paddy in 2 hectares of land of which 0.4 ha was leased-in at a cost of Rs.10000 per year. He invested Rs. 18000 on the pump house and thrashing floor which depreciated @ of 3 % per annum. He owned implements worth of Rs. 800, whose depreciation was @ 8% of its value/year. The interest rate for long-term borrowing was 8.5% and short term borrowing 11 %. Land revenue is Rs. 250/ha/year land cess is Rs.100/ha/year and water charges Rs. 50/ha/year. His family put 20 hrs of family male hrs and 15 female family labour days in the production process. He cultivated three crops per year. Calculate cost of cultivation and cost of production of paddy. Workout the various income measures of the paddy farmer.

The expenditure per ha is given below:

1. Seed: 60 Kg @ Rs. 18 per Kg.
2. Nursery Preparation: Bullock labour 8 hrs @ Rs.22.50 per hour.

   Human labour for land preparation 8 hrs @ **Rs.20.00** per hour.
3. Main field preparation: machine labour (Tractor) 2.3 hrs @ Rs.500.00 per hour.

   Human labour 48 hrs @ Rs.17.5 per hr.
4. Transplanting: Male labor 8 no's @ Rs. 100 per day; Female labor 35 @ Rs.60 per day
5. Fertilizers & Manure: FYM 6 tractor load @ Rs. 500 per tractor load

   Chemical fertilizers 500 Kg. @ Rs. 7.50 per Kg

   Application of fertilizers and manure: Male Labour 2 no's @ Rs. 100 per day.
6. Weeding: weedicide 1.25 liters @ Rs.380 per liter

   2 weeding @ 30 Female labour per weeding @ Rs.30 per female labour.
7. PP measures: 1 spraying @ 0.5 lit @ Rs.180 per liter and o.5 Kg fungicide @ Rs. 600 per kg; spraying charges: Rs.150 per spray.
8. Irrigation charges: 200 Kg of Paddy
9. Harvesting and thrashing: 3 hrs of combined harvester @ 1600 per hour
10. Yield: Grains 60 Quintals @ Rs.720 per Quintals; Straw 80 Qtls Rs. 50 per Quintal

Ex. No.: 08 Date:	**Estimation of Cost of Cultivation and Cost of Production of Perennial Crops / Horticultural Crops**

Estimating cost of cultivation for the perennial crops/ horticultural crops is different from estimation for annual crops. There are three major components in cost of cultivation estimation in perennial crops. The following points are to be considered while calculating the cost of cultivation per unit area and the cost of production for the perennial crops like mango, Guava, Lime, Coconut etc.,

1. **Establishment cost**: Expenditure on land preparation, pit making, soil filling, seedling, fertilizer, planting and setting up of irrigation system (traditional method, drip/sprinkler system) are considered in estimating the establishment cost which one time, in the first year.

2. **Maintenance cost**: The annual maintenance cost generally includes expenditure on pruning and other intercultural operation, weeding, fertilization, irrigation, operation cost on inter crops, if any, are to be considered and the costs are reoccurred in every year.

3. **Return:** Though the benefits/ return from the perennial crops start from third or fourth years onwards (mango, lime etc.,) in some cases return start from 5th year onwards (coconut etc). However, stabilization of the yield varies among crops.

The perennial crops give annual return or seasonal return in some cases. In case of tree crops like Casuarinas, Eucalyptus,Teak etc., harvesting / logging will take at the end of the period or after getting economic maturity which will take 7-15 years (Teak, Casuarinas).

Problem 1: Estimate the Cost of Cultivation and Cost of Production of Casuarina from the given details.

S. No.	Particulars	Unit	Qty.	Unit Rate (Rs.)	1st Year	2nd Year	3rd Year	4th Year	Total
A.	**Cost of Planting**								
1	Cost of initial ploughing	Hrs	7	400	2800	0	0	0	
2	Alignment and Digging of pits	MD	100	100	10,000	0	0	0	
3	Application of manure (Incl. cost	LS	2	1000	2,000	2000	2000	0	
4	Cost of Casuarina clones	Nos	4500	3	13500	0	0	0	
5	Refilling of pits, planting and Channel formation	MD	100	100	10000	0	0	0	
6	Causality replacement	MD	4	100	400	0	0	0	
7	Seedling cost	Nos	225	3	675	0	0	0	
B.	**Cost of Maintenance**								
1	Irrigation and Protection expenses	Months	4 MD x 12	1000	4800	4800	4800	3000	
2	Soil working and weeding	MD	50	100	5,000	5,000	0	0	
C.	**Fixed Expenses**								
	Depreciation of farm implements and buildings				3938	3938	3938	3938	
	Rental Value of owned Land				2500	2500	2500	2500	
	Imputed value of family labour				3500	3500	3500	3500	
	Interest on Fixed Capital other than Land				2357	2357	2357	2357	
D.	**Yield**	**Ton**						120	
	Price (Rs./ton)	**Ton**						**4000**	

Problem 2: Cost of Cultivation of Amla (Rs/ha) *Economic life Period is 25 years*

Sl.No.	Item of expenditure	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
I	**Materials**										
1	Planting material including transport	40138	4014	0	0	0	0	0	0	0	0
2	Drip Irrigation	106210	0	0	0	0	0	0	0	0	0
3	Fencing	61302	0	0	0	0	0	0	0	0	0
4	Cost of FYM	9263	8892	8892	9386	9386	9386	9386	9386	9386	9386
5	Cost of fertilizers	1455	2464	3449	4434	5588	5588	5588	5588	5588	5588
6	Plant protection	2470	2717	2470	2470	2470	2470	2470	2470	2470	2470
II	**Operations (Man days)**										
1	Land preparation	8645	0	0	0	0	0	0	0	0	0
2	Peg Marking & Digging of pits	55575	0	0	0	0	0	0	0	0	0
3	Planting and staking	9263	0	0	0	0	0	0	0	0	0
4	Manures & fertilizers application	1482	1853	2223	2470	2470	2470	2470	2470	2470	2470
5	Irrigation	1482	1235	1235	618	618	618	618	618	618	618
6	Appl. of plant protection	371	618	618	618	618	618	618	618	618	618
7	Intercultural	1853	2223	2470	1235	1235	1235	1235	1235	1235	1235
8	Harvesting	0	0	0	0	600	700	800	1000	1000	1000
9	Inter cropping	1853	0	0	0	0	0	0	0	0	0
III	**Fixed Expenses**										
	Depreciation of farm implements and buildings	2938	2938	2938	2938	2938	2938	2938	2938	2938	2938
	Rental Value of owned Land	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
	Imputed value of family labour	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
	Interest on Fixed Capital other than Land	1350	1350	1350	1350	1350	1350	1350	1350	1350	1350
	Yield (Kg/Tree)					5	15	25	50	75	100
	Yield (Kg/ha)					3125	9375	15625	31250	46875	62500
	Price (Rs/Kg)					10	10	10	10	10	10

For remaining years, the expenses and yield are same as that of 10th year

Ex. No.: 09 Date:	**Estimation of Cost and Returns of Livestock Products.**

A. ***Economics of maintenance of a pair of bullock/milch animal/Poultry birds***

The cost of maintenance involves both fixed and variable costs. The fixed cost includes depreciation on the value of the animal, interest on the value of the animal, cost of housing insurance and value of ropes. The variable cost consists of the value of fodder (both green and dry); feed (oil cakes, cotton seed, bran, feed mixtures, salt, minerals etc.), labour required for maintenance, veterinary and shoeing charges.

Steps

1. Work out the annual depreciation considering the economic life period and salvage value of the animals.
2. Work out the annual interest on the value of the animals.
3. Work out the (a) annual depreciation for the cattle shed, and (b) interest on the value of the cattle shed, (c) estimate the annual maintenance cost of the shed and the sum of the three items (a+b+c) constitute the annual cost of maintenance of the cattle shed. The total annual cost of maintenance of the shed should be divided by the number of animals housed in the shed to find out the share of each animal in the total cost of housing.
4. The annual insurance premium for the animals/shed should be estimated.
5. The sum of the above four items is the total annual fixed cost involved in maintaining the animal.
6. Estimate the total value of variable inputs used by the animals considering the quantity and price of these inputs.
7. The total cost of maintenance/annum can be estimated by adding the total annual fixed cost and total annual variable cost.
8. The value of dung produced by the animal per annum may be deducted from the total cost. To estimate the cost of maintenance/working day in the case of bullocks divide the net annual cost by the total number of days of work/annum.
9. In the case of milch animals to work out the cost of milk production the net cost of maintenance should be divided by the total amount of milk produced. (It is assumed that out of 12 months the lactation period is 10 months and dry period is 2 months).

Problem 1: From the data given below, work out the cost of production (COP) of milk and the net profit (NP) per year from a cow. Also calculate the BCR and break-even (BE) level of milk production. A dairy farmer rears 5 exotic cows, each one costing Rs.15000 each. The economic life period of cows is 10 years and after that it would be sold for Rs. 1000 for meat purpose. The insurance premium paid was 4% of the value of the cattle. The cattle shed was constructed at a cost of Rs. 50000 and the depreciation was calculated at 5 %of the value. The rate of interest was 10 % for long term loans and 12 %for short-term loans. Estimate COP, NP, BCR and BE for 12% increase in price of concentrate and 3% increase in Milk price.

The variable expenses for maintaining a cow was as follows:

Lactation Period

The green fodder requirement 25 Kg per day @ of Rs. 0.50 per kg

Concentrate 6 Kg per day @ of Rs. 6 per kg

Dry Period

The green fodder requirement 15 Kg per day @ of Rs. 0.50 per kg

Concentrate 2 Kg per day @ of Rs. 6.00 per kg

Other expenses performance animal

The dry fodder requirement 5 Kg per day @ of Rs. 1.00 per kg

Labour for maintenance 2 hrs @ of Rs. 12 per Hour.

Veterinary charges per year Rs. 300

Miscellaneous Expenses Rs. 300

The milk yield 8 liters @ Rs. 20 per Litre

The value of farmyard manure per annum Rs. 400

Net value of one-year-old calf is Rs. 600

B. ***Farm mechanization***

The cost of operating a machine includes both fixed and variable cost. The total annual fixed cost includes depreciation, interest on insurance. The variable cost comprises of the cost of fuel electricity, lubrication oil and wages for machinery operator.

i) ***Total annual fixed cost***

1. Work out the annual depreciation for the machine (Original value – salvage value)/life period.

$$\text{Average annual depreciation} = \frac{Original\ value - salvage\ value}{Life\ Period}$$

2. Work out the interest on the average value of the machine.

3. Estimate the cost of repairs and maintenance. It can be taken as 10 per cent of the average value of the machine.
4. Estimate the taxes and insurance premium paid/annum. It can be assumed as 2 per cent of the average of the machine.
5. Add the above four items to get total average annual fixed cost (TAFC)= 1+2+3+4
6. Work out the average fixed cost/hour by dividing the total annual fixed cost by the number of hours the machine is used /annum. (AFC = TAFC/ No. of hrs)

ii). *Running cost/hour*

1. Work all the value of fuel / electricity and lubricants consumed by the machine / hour.
2. Work out the wages/hour for the operator.

1. *Cost of performing an operation by machine*

Estimate the cost of operating the machine per hour by adding the average fixed cost / hour with the running cost/hr and this amount should be multiplied by the number of hours for which the machinery is used to perform that particular operation.

From the given data, work out the cost of spraying one ha of silk cotton with power sprayer. The total number of spraying given is 10 and the average time taken/spraying is 2 hours. Four labour hours are required / spraying and the cost of labour / hour is Rs.100.

Cost of power sprayer	:	Rs.7000
Useful life period	:	2500 hours (10 years)
Salvage value	:	Rs.400
Fuel requirement	:	1 lit of petrol/hour
Lubricating oil	:	25ml/lit. of petrol
Cost of petrol	:	Rs.70.00/lit
Cost of lubricating oil	:	Rs.86.00/lit
Hire charge	:	Rs.75/hrs

Ex. No.: 10 Date:	**Preparation of Farm Plan and Budget**

Farm Planning

Farm planning is a decision-making process in the farm business, which involves organization and management of limited resources to realize the specified goals continuously. Farm planning involves selecting the most profitable course of action from among all possible alternatives.

Objectives of Farm Planning

The ultimate objective of farm planning is the improvement in the standard of living of the farmer and immediate goal is to maximize the net incomes of the farmer through improved resource use planning. In short, the main objective is to maximize the annual net income sustained over a long period of time. The farm planning helps the cultivator in the following ways:

a) It helps him examine carefully his existing resource situation and past experiences as a basis for deciding which of the new alternative enterprises and methods fit his situation in the best way.
b) It helps him identify the various supply needs for the existing and improved plans.
c) It helps him find out the credit needs, if any, of the new plan.
d) It gives an idea of the expected income after repayment of loans, meeting out the expenditure on production, marketing, consumption, etc.
e) A properly thought of a farm plan might provide cash incomes at points of time when they may be most needed at the farm.

A farm plan is a programme of total farm activities of a farmer drawn out in advance. An optimum farm plan will satisfy all the resource constraints at the farm level and yield the maximum profit.

Characteristics of a Good Farm Plan

A good farm plan generally should have the following characteristics:

a) An element of flexibility in a farm plan is essential to account for changes in the environment around the farm.
b) A farm plan should maximize the resource use efficiency at the farm.
c) It should provide for the attainment of the objectives of profit maximization through optimum resource use and balanced combination of farm enterprises.
d) Risk and uncertainty can be accounted for in a good farm plan.
e) The plan helps in timely acquisition and repayment of farm credit.

A successful farm business is not a result of chance factor. Good weather and good prices help but a profitable and growing business is the product of good planning. With recent technological developments in agriculture, farming has become more complex business and requires careful planning for successful organization. A farm plan is a scheme for the organization and operation of the farm business and it involves the physical component of the farm decisions.

A farm plan is a programme of total farm activity of a farmer drawn up in advance. A farm plan should show the enterprises to be taken up on the farm; the practices to be followed in their productive use of labour, investments to be made and similar other details

Farm planning enables the farmer to achieve his objectives (Profit maximization or cost minimization) in a more organized manner. It also helps in the analysis of existing resources and their allocation for achieving higher resource use efficiency, farm income and farm family welfare. Farm planning is an approach which introduces desirable changes in farm organization and operation and makes farm a viable unit.

Type of Farm Plans

1. Simple farm planning: It is adopted either for a part of the land or for one enterprise or to substitute one resource to another. This is very simple and easy to implement. The process of change should always begin with these simple plans.

2. Complete or whole farm planning: This is the planning for the whole farm. This planning is adopted when major changes are contemplated in the existing organization of farm business.

It refers to making out a plan for the farm as a whole or for all decisions on one enterprise. In case the budgeting analysis involves complete reorganization of the farm business, it is caned complete budgeting. Complete budgeting considers all the crops, and livestock, producing methods, estimates of costs and returns for the farm as a whole

Steps involved in complete plan

1. **Estimation of expected yield, costs and prices:** For different proposed enterprises the expected yield, cost of various inputs and prices of output are to be taken.
2. **Availability of farm resources:** The existing resources especially land suitability for various crops, labour in different time periods, various forms of capital etc are to be estimated.
3. **Existing enterprise mix and input use:** What crops are being raised on each field and use of different inputs and crop practices followed are also recorded in detail.
4. **Weaknesses in the existing plan:** In terms of crop pattern and practices, the weakness in existing plan is written in detail.
5. **Preparation alternate plans:** Considering the existing plan and its weaknesses and net return

from proposed enterprises as well, the alternate plans which promise higher net returns are prepared.

6. **Selecting the best plan:** The most suitable plan which promises the highest return with minimum risk is selected.

7. **Implementation of selected plan:** The resource requirements for the selected plan are estimated and arrangements are made for their availability at required time such that the selected plan may be implemented.

Farm Budgeting

Farm budgeting is a method or analyzing plans for the use of agricultural resources available with the farmer.

Types of Farm Budgeting

There are two types of farm budgeting.

a. Partial budgeting - enterprise budgeting and

b. Complete budgeting

a. ***Partial Budgeting***

For taking a specific farm management decision, the help of partial budgets are essential. Partial budgeting is a statement of added cost and added returns as a result of change in one or few activities of the farm such as increase or decrease in the level of enterprise, introduction of a new enterprise or adoption of new technology/ machinery over the old one *etc.*, For example,

1. Substitution between enterprises e.g. sugarcane for paddy
2. Substitution between factors input e.g. machinery for labour
3. Changes in farm practices e.g. direct selling of papaya or extracting papain and then selling.

Under partial budgeting, the credit and debit aspects of such changes are analyzed.

Credit side

Extra revenue is based on net additional yield of main product and arriving at the value of additional output obtained by the farmer at the time of harvest. If the product is for sale, marketing costs are deducted. Another aspect of credit is in terms of reduction of cost.

Debit side

Extra cost denotes the value given up to bring the extra input. For purchased inputs, market price is considered and for owned resources, the opportunity cost is considered. The other aspect of debit is reduction in revenue.

Illustration

A farmer in Vilathikulam block of Tuticorin district is cultivating traditional irrigated Chillies. A new improved variety of Chillies has been released for adoption. The cost of cultivation and input requirements are supplied by Agricultural Development Officer of the block. The cost and returns for traditional varieties is available with the farmer from his previous experience. The farmer compares the traditional and improved variety with the partial budgeting technique as detailed below.

Partial Budget showing change from traditional chillies (K2) to Improved Chillies cultivation

	Debit (A)		**Credit (B)**	
1.	**Added Cost**	**Amount (Rs)**	**Added return**	**Amount (Rs)**
i.	Human labour	1645	Gross return (Difference between the gross return of K2 chillies and improved chillies per hectare)	11703
ii	Bullock labour	1275		
iii	Manures and Fertilizers	1319		
iv.	Pesticide	1199		
v	Irrigation	124		
vi	Interest on working capital	50		
II	**Reduced return**	Nil	**Reduced Cost**	1580
	A. Total added cost and reduced return	5562	B. Total added return and reduced cost	13283

Net change in income: B - A = Rs.7721

Since cultivation of improved variety gives an additional income of Rs.7721 per hectare compared to traditional one the farmer decides to switch over to the improved one.

b. *Complete budgeting*

It refers to making out a plan for the farm as a whole or for all decisions on one enterprise. In case the budgeting analysis involves complete reorganization of the farm business, it is called complete budgeting. Complete budgeting considers all the crops, and livestock, producing methods, estimates of costs and returns for the farm as a whole.

Steps involved in complete budgeting

1. **Estimation of expected yield, costs and prices**: For different proposed enterprises the expected yield, cost of various inputs and prices of output are to be taken.
2. **Availability of farm resources**: The existing resources especially land suitability for various crops, labour in different time periods, various forms of capital etc are to be estimated.

3. **Existing enterprise mix and input use**: What crops are being raised on each field and use of different inputs and crop practices followed are also recorded in detail.
4. **Weaknesses in the existing plan**: In terms of crop pattern and practices, the weakness in the existing plan are written in detail.
5. **Preparing alternate plans**: Considering the existing plan and its weaknesses and net return from proposed enterprises as well, the alternate plans which promise higher net returns are prepared.
6. **Selecting the best plan**: The most suitable plan which promise the highest return with minimum risk is selected.
7. **Implementation of selected plan**: The resource requirements for the selected plan are estimated and arrangements are made for their availability at required time such that the selected plan may be implemented.

1. *Assignment for Farm Planning:*

Assignment: Prepare complete farm plan for a farmer in western zone having 1 ha of wet land, 2 ha garden land and 1 ha of dry land. Farm plan must include both cereals, pulses and other commercial crops like sugarcane and turmeric with the livestock component. A farmer is having a bore well which support for 3 ha and has no capital constraints.

2Assignment for Budgeting:

A. Partial Budgeting: Factor- Substitution- Hand weeding Vs herbicides application

Farmers growing Bhendi usually take up hand weeding employing women labour. The labour requirement per hectare is 60 women days. The Department of Agriculture recommends application of one litre of herbicides per acre followed by a hand weeding which required only 25 women days/ha. The wage rate /women day is Rs 200. The cost of application of herbicides is Rs 200. The cost of herbicides is Rs 800 per lit. There is a 200 kg of additional Bhendi yield in case of pre-emergent herbicide application to the crop. The sale price of Bhendi is Rs 12 per kg. Suggest the farmers the most economical method of weed control (a) with additional yield (b) without additional yield.

B. Using partial budgeting, suggest the farmer whether to go for hybrid Tomato in place of local variety. The costs and returns per ha for the variety and hybrid are furnished below.

S.No	**Particulars**	**Local Variety Rs/ha**	**Hybrids Rs/ha**
	Seeds/planting material	6855	10857
	Manures and Fertilizers	26939	32584
	Plant Protection	8906	8572
	Irrigation expenses	750	750
	Value of machine labour	7410	7410
	Value of human labour	48735	50726
	Interest on Working Capital (7%)		
	Yield (Ton/Ha)	20	25
	Price / Kg	10	10

Ex. No.: 11 Date:	Farm Records and Accounts: Usefulness, Types of Farm Records– Farm Production Records-Farm Financial Records

Management of a farm business requires a wide range of information on physical and financial performance. Farm book-keeping is known as a system of records written to furnish a history of the business transactions, with special reference to its financial side. Records and accounts help in evaluating the performance of the farm business, obtaining credit from financial institutions, filing tax returns, evaluation of investment alternatives etc.

i. *Advantages of farm records and accounts*

The various advantages of keeping systematic farm records can be described as under:

1. *Means to higher income*

To obtain higher income, farmers must have exact knowledge about present and potential gross income and operating costs.

2. *Basis for diagnosis and planning*

Diagnosis of management problems is the pre-requisites of sound planning. Records and accounts provide the basic information needed for such a diagnosis.

3. *Way to improve managerial ability of the farmer*

The farmer gets a better insight into the working of his business, and farmer can avoid mistakes and losses.

4. *Basis for credit acquisition and management*

Properly kept records and accounts can demonstrate and authenticate the production and income potentials and credit worthiness of the farmer.

5. *Guide to better home management*

Records and accounts provide information on farm-household economy. Analysis of farm records provides good guides for the allocation of resources between production improvement and immediate family welfare.

6. *Basis of conducting research in Agricultural Economics and production economics*

Research requires precise and correct data which is possible only proper records and accounts are maintained on the farm.

7. *Basis for government policies*

The farmers need to continuously feed the facts for state and nation, farm policies such as land policies, price policies, and crop insurance, etc.

ii. *Problems in Farm Accounting*

a) As Indian farmers carry out only subsistence nature of farming, recording is not essential to them.

b) Indian farmer acts as an owner, manager and labourer. Hence, recording becomes complex.

c) Illiteracy and lack of business awareness of farmers prohibit them to have farm records.

d) Fear of taxation prevents farmers from recording and accounting the information.

e) Forecasting becomes complicated because of very high risk and uncertainties involved in farming.

A good system of accounts for any farm is one that enables recording information that the farmer needs and also permits the desired analysis of the information recorded.

Systems of Book-Keeping

There are two systems of farm accountancy: *(i)* double entry system, and (ii) single entry system.

Double entry system

It is a method of recording each transaction in the books of accounts in its two fold aspects, i.e. two entries are made for each transaction in the same set of books, one being a debit entry and the other a credit entry.

Single entry system

This is the system which ignores the double effect of transactions. Only personal accounts of debtors and creditors are kept and impersonal accounts are ignored altogether.

3. Types of Farm records: Farm records are usually of the following types:

(i) Farm inventory; (ii) Physical farm records; (iii) Financial farm records

There are many different kinds of farm records and accounts, each of which can be adopted for a given purpose on a particular farm situation.

Farm inventory refers to the listing down the items possessed by the farm on a specified date which includes inventory of crop and livestock, inventory of farm machinery, and farm building.

Physical Farm Records

Physical records are related to the physical aspects of the operation of a farm business. They do not indicate financial position or the outcome of the farm business, but simply record the physical efficiency or performance of the farm.

Physical farm records normally include the following records:

ii) Farm map, soil map and contour map, Stock register.
iii) Charts on physical efficiency,
iv) Land utilization record,
v) Farm production and disposal record, Input registers,
vi) Labour records, daily work diary and machinery use records.

Financial Farm Records which deal with the financial transactions can be recorded in four main types of accounts. (a) Accounts dealing with external agencies; (b) Accounts dealing with capital investment; (c) Operation accounts; and (d) Service accounts

The Following are the farm records maintained by the co-operate farms and state farms.

1. Forecast register

Field	**Area**	**Nature of work**	**Wage rates and labourers forecasted**					
			Skilled labourers	**Wage rate (in Rs.)**	**Semi Skilled Labourers**	**Wages rate (in Rs.)**	**Unskilled labourers**	**Wage rate (in Rs.)**

Amount

Skilled Labourers	**Amount (in Rs.)**	**Semi-Skilled Labourers**	**Amount (in Rs.)**	**Unskilled labourers**	**Amount (in Rs.)**

This is prepared a day in advance of the actual labour requirement on the farm. Keeping in view of the various operation to be performed for various crops, the requirements is forecasted. The labour units indicated in this register should not exceed the labour units given in DMS.

2. Daily memorandum sheet (DMS)

Field	Purpose of work	Allotment of labourers						
		Skilled	Wages (inRs.)	Semi Skilled	Wages (in Rs.)	Unskilled	Wages (in Rs.)	Amount (in Rs.

This deals with the distribution of work in a day along the labour units employed and the wages paid for various operations.

3. Muster Sheets

S.No	Name of the casual labourers	Sex	Nature of work	No. of days worked in a fortnight 1 2 3 …..15	No.of days	Wages rate/day (in Rs.)	Amount (in Rs.)

The particulars of the labour units employed including the number of days employed and the wage bills are posted in these sheets. These sheets give an idea of fortnightly expenditure incurred on the labour wages.

4. Permanent Dead Stock Register

Date	Particulars	Receipts	Issues	Balance

5. Temporary Dead Stock Register

Date	Particulars	Receipts	Issues	Balance

This register gives the managements an idea of the stock issued and balance available so that future requirements can be assessed and undertake the purchase as and when required.

6. Fertilizer and chemicals register

S.No	Date	Particulars	Receipts	Issues	Balance

The details of the different fertilizer purchased along with the purpose for which they are issued are posted here. This register presents the position of the stock of fertilizers and chemicals available at any given point of time.

7. Seed stock register (grams/kgs/nos.)

Date	Particulars	Receipts	Issues	Balance

This register gives the details of the purchases, issues and balance of the seeds of different varieties of crops grown on the farm.

8. FYM and cattle feed register (kgs/tonnes)

S.No	Date	Particulars	Receipts	Issues	Balance

This register deals with the particulars of receipts, issues and balance of FYM and cattle feed.

9. Tractor expenditure register(Rs)

Date	Particulars	Receipts	Issues	Balance

This register contains the information pertaining to the purchase of items like diesel, spare parts, etc and their use as per the requirements. The stock position of the same is also available in this register.

10. Livestock Register

Date of purchase	From whom purchased/received	Description of the animal	Date of birth	Book value (in Rs)

The description of the animal along with the source of obtaining the same and date of birth of the animal and value are entered here.

11. Farm produce stock register

S. No	Dry land/ Wet land	Season crop variety	Main product (Qtls/ tonnes)	Entered in page no. of produce stock register	Signature of the store keeper	Signature of the farm superintendent

The details of crop wise and variety wise main product and by product are entered here. This gives an account of the total product obtained from the farm.

12. Produce stock register

Date	Issue/sale	Receipts	Issues	Balance

The information posted in the farm produce stock register is brought over here. Under the column "receipts" the quantity recorded in the farm produce stock register is entered here. The issue column indicates the details as to whether the produce was issued to the farm or sold.

13. Indent register

Indent No.	Date	Particulars	Quantity	Purpose	Receiver	Indent	Signature of the store keeper	Signature of the farm superintendent

The register presents the indents that are made. Under the column "purpose", if the input indented is fertilizers, the crop to which it is proposed to be applied is entered here. This register holds good for all farm supplies.

14. Sales price register

S.No.	Name of the product	Quantity proposed for sale	Rates furnished by the secretary, Regulated market committee (Rs)	Rate per unit in the local market (Rs)	Rate at which disposed(Rs)

Sales particulars of the produce obtained on the farm are found in this register. The rates furnished by the agricultural market committee and that of local markets are obtained and then the rates at which produce was disposed is entered. This type of information is mostly seen in the Government farms.

15. Sanction Register

S.No.	Date	Particulars cum purpose of expenditure	Quantity	Rate (unit price Rs.)	Amt to be Sanctioned (Rs.)	Head of the Account	Signature of farm manager	Signature of sanctioning authority

It provides the details of the items of expenditure along with the rate per unit and amount to be sanctioned. The proposed items are purchased after due sanction from the concerned authorities.

16. Auction Register

S.No	Name of the bidder	Address of the bidder	Amount (Rs.)	Signature of the bidder	Amount deposited (Rs.)	Signature of the successful bidder

The information of those items, which are auctioned, can be known from the auction register.

17. Cash book

Date	**Opening Balance**	**Sales bill No.**	**Amount (Rs.)**	**Amount remitted to the bank (Rs.)**	**Cash on hand (Rs.)**

The details of cash remittances and cash on hand are shown here.

Thus the main objectivity of maintaining the records is to control the farm business, guide future decisions and provide data required for sound farm planning.

Assignment:

Observe the types of records maintained in TNAU farm and give brief note on it.

Ex. No.: 12 **Date:**	**Preparation of Cash Flow Statement**

The cash flow statement is the other important financial document needed to analyze the financial position of the farm business. The cash flow statement examines the amount of cash available to the farm and his family (both farm and non-farm) and how that cash is utilized in both farm and non-farm activities. It can be prepared either on annual basis, or more a frequent basis such as quarterly or monthly.

Hence, cash flow statement is a month by month or quarter by quarter comparison of the expected cash income and expected cash expenses at the end of the each month or quarter.

Importance

1. It is helpful to know whether the cash will be available when it is needed.
2. If surplus cash exists where the farm operator would deposit the funds or invest the funds or repay the loan borrowed.
3. It helps to decide the magnitude of borrowing, timing of borrowing the funds or invest the funds.
4. It helps to know the potential effects that marketing factors have on the need for borrowed funds.

Components of Cash flow statement

I. Beginning cash balance

II. Cash inflows

It means returns or amount received from the investment. It includes the amount received by the farmer through the sale of crop and livestock products and by way of borrowing and income from other sources i.e., off farm and non-farm income.

Total cash available excluding borrowing

a. Beginning cash balance
b. Farm operating receipts
c. Capital receipts
d. Income from other sources
e. New operating loans and crop loans
f. New intermediate and long-term loans

III. *Cash outflows: Total cash required excluding*

a. Principal repayment
b. Variable cash expenses
c. Fixed cash expenses
d. Capital expenditures
e. Non -farm Investment
f. Personal expenses
g. Repayment of loans

IV. ***Ending Cash Balance: Total Cash Inflow – Total Cash Outflow***

FORMAT OF CASH FLOW STATEMENT

S. No.	Item	Quarter			
		I (July – Sep)	II (Oct –Dec)	III (Jan –	IV (Apr –June)
A	**Cash Inflows**				
1.	Beginning Cash Balance				
2.	**Farm operating receipts**				
	Crop sales				
	Sale of livestock products				
	Income from other sources				
3.	**Capital receipts**				
	Sale of livestock				
	Sale of machinery				
	Sale of land / real estate				
4.	**Non-farm income**				
	Wages and salaries				
	Dividends and interests				
	Sale of bonds and stocks				
	Total cash available (1+2+3 + 4)				
B.	**Cash Outflows**				
1.	**Variable cash expenses**				
	Purchase of seeds				
	Rent				
	Diesel				
	Fertilizer				
	Plant protection chemicals				
	Interest on operating loans intermediate and long term loan				
	Sub total				
2.	**Fixed cash expenses**				
	Taxes				
	Maintenance cost				
	Insurance				
	Interest on intermediate and long term loan				
	Sub total				
3.	**Capital Outflows**				

	Purchase of livestock				
	Purchase of machinery				
	Purchase of land				
	Sub total				
4.	**Non-farm investment**				
	Purchase of stocks and bonds				
	LIC savings				
	Sub total				
C.	**PERSONAL EXPENSES**				
	Income tax				
	Family living expenses				
	Sub total				
D.	**LOANS**				
	Total cash outflows (B+C+D)				
E.	**ENDING CASH BALANCE** **=**Cash inflow – Cash outflow				

Problem 1: Using the information prepare a cash flow statement and offer your comments on the availability of finance.

S. No	Particulars	I quarter (June- Aug)	II quarter (Sep.- Nov.)	III quarter (Dec. – Feb)	IV quarter (Mar. – May)	Total
	I Cash receipts (in Rs.)					
1	Cash Balance Brought	3,000	-	-	-	**3,000**
2	Total operating sales (farm and live stock Products)	1,350	1,400	30,200	7,800	40,750
3	Total capital sales (Milch	-	5,000	-	-	5,000
4	Non-farm income (Family members Working	2,000	1,500	2,000	3,200	8,700
5	Borrowings (ST, MT and LT loans From institutional	7,500	-	-	-	7,500
6	**Total**					
	II Cash expenses (in Rs.)					
1	Operating expenses	8,500	6,750	6,200	5,300	26,750
2	Capital investment (purchase of milch cattle)	-	-	6,000	-	6,000
3	Family living expenses	2,400	2,800	3,200	3,000	11,400
4	Payment of previous Years debt	500				500
5	Payment of ST loans and installments on investment loans	-	-	7,968	-	7,968
	Total					
	III Cash balance (in Rs.)					

Ex. No.: 13 **Date:**	**Preparation and Analysis of Net worth Statement and Profit and Loss statement**

Financial Analysis involves maintaining and using records and other information needed to measure the financial performance of the business. The most widely used financial statements are (i) Net worth statement or balance sheet, (ii) profit loss statement or Income statement and iii) cash flow statement.

A. *Balance sheet*

Balance sheet is a summary of assets and liabilities of the business, together with a statement of the owner's equity or net worth. (or) It is a systematic list of all assets and liabilities of the business. A fundamental accounting equation balances the net worth statement. Total assets are always equal to the sum of total liabilities and net worth.

Total assets = Total liabilities + Net worth.

The equation indicates value of claims on Total assets by the owner and creditors is equal to the values of the total assets.

Balance sheet represents the financial condition of the business on a particular date. Hence it is compared to a 'snapshot' which gives the picture in a specific moment in time. The income and cash flow statements are like moving pictures that give the performance of the business over time. Net worth is placed on liability side showing owner, like creditor has a claim against the total assets equal to net worth. Hence net worth is actually a liability that owes to the owner just as debts (liabilities) owes to lenders.

Net worth is present only when assets are greater than liabilities. If liabilities are greater than assets, then the difference is called net deficit and it is placed on the asset side of the balance sheet. If represent the shortage of assets with reference to the liabilities. Classification of Assets and Liabilities

Characteristics of balance sheet

1. They record values at a specific point of time
2. The timing of balance sheet vary according to the timing of business year
3. Most balance sheets report a date of December 31st
4. If the business year does not correspond with a calendar year, the year-end balance sheet would report a different date. The date should be chosen such that two successive balance sheet represent the beginning and end points of time covered by the intervening balance sheet.

5. The net worth statement in principle is a simple document. It consists of three main parts (a) Assets (b) Liabilities and (c) Owner's equity (or) Net worth

A. Assets: Assets include all items of property having a money value, which are in the legal possession of the farmer including all claims against the property of others. (Value of things owned). An asset can be defined as anything of value (money) in possession of farm business. Farm assets can broadly be classified into following three categories

1. Current Assets: They are defined as cash and other items where values are reasonably expected to be realized in cash, sold or consumed during the normal operating cycle of the business usually one year. The liquidation of these items will have the least effect on the business ability of the individual or firm to continue operating. Marketable securities, accounts and notes receivable, prepaid expenses and inventory which are expected to be converted into cash or accounts receivable during the year are included under current assets. The term inventory includes farm products awaiting sales, products in the process of production or goods to be used directly or indirectly in production. Eg. Feed, seed, farm supplies, standing crops, crop and livestock products kept for sale, cash on hand, accounts receivable etc.,

Note: Many current assets have the same value whether recorded on cost basis or on current market value basis except stocks and bonds.

2. Intermediate or working Assets: These are items that can be liquidated but generally would require more time to achieve a fair price and also would have a significant influence on ability to continue in its basic format of operation. Items of this nature include draught animal, milch animal and livestock in growing stage to be sold in later years, machinery, equipment, movable farm assets and equity capital invested in cooperative societies etc. In a sense, these items are basically intended to support production and are not intended for sale. Because of this, intermediate assets are somewhat more difficult to liquidate than current assets and if liquidated, nature of farming operation would be modified to a greater extent. For e.g. liquidating the draught animal would certainly have a major impact on farming activity. The assets will be valued by deducting the depreciation cost.

3. Long term Assets: The long-term assets of the business are the major assets. eg. Land, buildings. If a major portion of these assets were liquidated, the business would have to be terminated. These assets are the least likely to be liquidated. Valuation based on cost or current market value can have a tremendous impact on the rupee amount recorded for these assets.

B. Liabilities: Liabilities include all legal claims by others to the property or income of an individual. It is the debts owned.

1. Current Liability / Short term Liability: Short term liabilities are those claims (debts) on the business which will become due (payable) during the next production period or accounting period. eg:- crop loans, interest payments for LT Loans etc.

2. Intermediate Liabilities: Intermediate liabilities are those claims, which will be paid, generally over a period of two to ten years. eg: Medium term Loans taken for purchase of machinery, breeding livestock etc. for which repayment period is 2 to 5 – 7 years.

3. Long term Liabilities: Long term Liabilities are those claims on the business, which will be paid over a period of greater than ten years. eg: LT Loans taken for permanent improvements on the farm.

4. Contingent liabilities: These are obligations which become due only under specific circumstances. A common contingent liability is capital gain taxes. These taxes become due only if the capital assets sold.

C. Net worth / Owner Equity: It represents the residual entry in the account, which balances the statement. Net worth = Total Assets – Total Liabilities

Net worth is an indication of the amount of equity the owner has in the business and is considered to be the balancing entry of net worth statement. In some cases, liabilities exceed the assets of the business. In this situation the business has a negative net worth and the balancing entry is defined as net deficit. The net worth statement is one of the primary documents used by lending agencies in evaluating requests for new loans or extension of existing loans.

From the balance sheet, the following ratios can be worked out.

Analyzing the Balance sheet/ Net worth Statement Concepts

Liquidity: Liquidity relates to the firm's capacity to generate sufficient cash to meet its financial commitments (market transactions and cash obligations) as and when they become due. Liquidity is a short run concept.

Solvency: A firm is solvent when the current market value of its assets exceeds its debt obligations and it is able to meet these debt obligations over a sufficiently long period of time. It is defined as a value which would have left after all assets are converted into cash and debts are cleared or repaid.

A solvent firm may either be liquid or illiquid. Conversely it may be insolvent and either liquid or illiquid. Ratio analysis is not only facilitates comparison among different firms but also helps in comparing the same firm over a period of time.

Ratio can be broadly classified into Liquidity and Solvency ratios.

Liquidity ratio	**Remarks**
1 Current ratio= Current assets (CA) /	Higher the ratio the more liquid the farm business
2. Intermediate ratio (IR)=(CA+IA)/(CL+IL)	A farm with CR and IR less than 1 may be facing
3. Debt structure ratio = Current Liability (CL) / Total liability	Lower the ratio higher liquid the farm business
4. Acid test ratio= (Current assets –Value	To compare two firm with equal current ratio. The low
Solvency ratio	
1. Leverage ratio (LR)= TA/ Net worth	Higher the ratio larger the claims on firms relative to its equity. Leverage ratio of 2 indicates that every rupee
2. Net capital ratio (NCR)= TA/TL	Greater than one indicates the ability of the firm to generate sufficient amount to repay total liability. It also gives the long run
3.Dept equity ratio	Lesser the ratios larger the debt structure
4. Equity-value ratio (EVR)= NW/TA	Where, TL= total liability; NW=Net worth ; TA= Total

The net capital ratio, debt-equity ratio and equity-value ratio are indicators of long term solvency of the business. These ratios indicate a manager's willingness to use borrowed capital in the operation of his business.

If the net capital ratio works out to less than one, the farm is using more of borrowed funds. e.g. for the farm that has relatively stable expense and income situations, such as dairy farm, lending institutions may be willing to advance credit even with NCR as low as 1.0. In other business such as orchards where income and expense fluctuate greatly from year to year financial institutions might consider a NCR of 2 or 3 as a more appropriate value, for advancing loans.

Again, the direction of movement of these ratios through time is more important.

i. NCR should be increasing over time.

ii. Debt equity ratio should be decreasing over time. Equity ratio approaching 1, would be making progress towards higher solvency levels

Balance /sheet of a Hypothetical Farm

Assets	**Amou**	**Liabilities**	**Amo**
Current assets		**Current liabilities**	
Cash on hand	10,000	Crop loans to be repaid to Institutional agencies	8,000
Savings in bank	8	Accounts payable	11,00
Value of grains ready for disposal	3 5,		
Livestock Products (eggs, birds, etc)	6 0,	Hand loans	5,000
Fruits, Vegetables, fodder And feed	8 ,	Money owed to input Suppliers	25,00 0
Value of bonds and Shares to be	2 ,	Annual installments of MT and LT loans	19,00 0
Sub-	1,2	**Sub-Total**	68,00
Intermediate assets		**Intermediate liabilities**	
Dairy cattle	1 0	Livestock loan (Outstanding	8,000
Bullocks	9 ,	Machinery loan (Outstanding	15,00 0
Poultry birds	1 5,	Unsecured loans (outstanding amount)	10,00 0
Machinery and equipment's	15 ,0		
Tractor	1,75		
Sub – Total	2,2	Sub – Total	33,00
Long term assets		**Long term liabilities**	
Land	6,00 ,000	Tractor loan (outstanding amount)	1,20, 000
Farm buildings	25 ,0	Orchard loan (outstanding amount)	25,00 0
		Unsecured loans (land development)	10,00 0
Sub total	6,25	Sub total	1,55,
Total of assets	9,75	Total of liabilities	2,56,
		Net worth or equity	7,19,
		Total of liabilities + net	9,75,

Problem 1: Classify the assets and liabilities in the given problem and prepare a balance sheet. Comment on the net worth of the business.

A farmer has 13.50 acres of land of which, 10 acres are dry land that has a market value of

Rs. 8,000/ ac, 3 acres are garden land and value is Rs. 40,000 per acres and 0.50 acres of wetland worth Rs.40,000/acre. He has mortgaged land worth of Rs.40, 000 with the Land Development Bank. He has established a mango garden in 1.00 acre ten years back. It is worth Rs.20,000. He has a standing crops and other inputs stored to the value of Rs.30,000. He has in hisstore, cotton worth of Rs.5,000 meant for sale. The farmer has a bullock cart valued at Rs.7,000 and a pair of bullocks worth Rs.10,000. He has purchased the bullocks on loan and the balanceto be paid is Rs.7,000. He has a milch animal for home consumption worth of Rs.4,500. The Farm has an oil engine worth of Rs.7,000. The farmer has to repay Rs.15,000 on the crop loan and Rs.4,000 in long term loan. He has a bank balance of Rs.2,500, cash Rs.1,500 and accounts receivable of Rs.1,500.

B. ***Income Statement / Profit Loss Statement***

The income statement or profit and loss statement is an important financial record that measures financial progress and profitability of business over time. The income statement is a summary of both the cash and non-cash financial transactions of the farm business, which occurred during the selected accounting period. This document is important because it is extensively used in analyzing the profitability, efficiency and financial stability of the business. Information from this document is also used in the preparation of cash flow summary.

Importance

1. It is used to identify net cash farm income
2. It is useful for identifying information needed in preparing income tax returns and analyzing the cash flows generated by the farm business apart from non-farm sources.
3. It is useful in analyzing the relationship between cash and non- cash sources of income.
4. The income statement is otherwise called as profit and loss statement because it measures the net income or loss of the farm business.

Components of Income statement

1. Cash farm receipt
2. Cash farm expenses
3. Adjustments for changes in inventory and capital assets
4. Non -cash farm income

The income statement is divided into two major sections namely income and expenses.

A. ***Incom***

e Cash

Receipts

It includes receipts from sale of any agricultural produce, livestock and livestock products.

Inventory: (Eg.) Seeds, fertilizers, grains under storage

Capital assets: (Eg.) Machinery and livestock

The sale of milch animal and equipment are major items. The receipts from sale of these items are separated from normal cash receipts and they are called as net -capital gain.

Non-farm income

Income derived from activities not related to agriculture. It includes interest from loans, dividends, salaries from other jobs etc.,

Off farm income

Income derived from activities related to agriculture but not from farming activities. It includes wages from hiring out of labour for agriculture activities.

B. *Expenditures*

The other major section of the income statement relates to the expenses of the business.

i) *Cash farm expenses*

It includes expenses incurred for meeting variable cash expenses such as purchase of seed, fertilizers, plant protection chemicals and fixed cash expenses like water tax, land tax, insurance etc.,

(a) Operating expenses are cash expenses, which generally vary with size of the business operation.

(b) Fixed expenses do not vary significantly with a change in the volume of business done under the period of reporting.

The sum of operating and fixed expenses is the cash farm expenses of the business.

ii) Total Farm Expenses is the sum of cash and non-cash income of the farm.

iii) Total Expenses is the sum of farm and family expenditures family.

Format of the income statement

Sl.No	Income	Value (RS)	Sl.No	Expenditure	Value (RS)
I	Cash farm revenue		I	Cash farm expenses	
				Variable cash expenses	
				Fixed cash expenses	
II	Net Capital gains income		II	Non cash adjustments on capital	
III	Total cash farm revenue		III	Total farm expenses	
IV	Non-farm income		IV	Family expenses	
V	Off-farm income				
	Total income			**Total expenses**	

Net Cash farm income = Total Cash farm income - Total cash farm expenses

Net Farm Income = Total farm income - Total farm expenses

Total Net Income = Total income - Total expenses

Income Statement of a Hypothetical Farm

Particulars	**Amount (in**
I. Receipts	
A. Returns from the sale of crop output	52,000
B. i. Revenue from milk and milk products	5,000
ii. Returns from poultry enterprise	12,000
Returns from supplementary enterprises	17,000
C. Gifts	2,000
D. Gross cash income	71,000
Appreciation on the value of assets	3,000
Gross income	74,000
II Expenses	
Operating expenses or costs	
A. Hired human labour	10,500
B. Bullock labour	900
C. Machine labour	1,500
D. Seeds	1,100
E. Feeds	5,000
F. Manures & fertilizers	3,000
G. Plant Protection measures	1,550
H. Veterinary aid	500
I. Irrigation	250
J. Miscellaneous	2,000
K. Interest on working capital	2,100
Total operating	**28,400**

Problem 1: Prepare a profit or loss statement using the following information and work out the net profit or loss.

Mr.Subbu owns 6 acres of agricultural land. He cultivated paddy, sugarcane and groundnut during the year. He had sold 30 quintals of paddy @ Rs.1000 per quintal, 16 tonnes of sugarcane @ Rs.1500 per tonne, and 20 quintals of groundnut @ Rs.2500 /qtl. He has two milch animals and a pair of draught animal. The milk sale fetched him Rs.10,000 during the year. He has taken up a small broiler enterprise with 200 birds. He sold the birds at the rate of Rs.60 per bird. He hired out the draught animal and earns Rs.10,000. He sold out a milch animal for Rs.15,000 and another home bred animal for Rs.8,000 . He disposed of the old implements available in his farm for Rs.5000. He has stored 16.67 quintals of paddy produced during the last year. He incured a loss of Rs.2,000 in selling the milch animal.

His **expenses** are as follows:

S No	Details	Amount (Rs)	SNo	Details	Amount (Rs)
1.	Land rent	5,000	9	Irrigation structure repairs	4500
2.	Attached farm servants	2,000	10	Marketing expenses	1800
3.	Hired labour	6,000	11	Interest on current dept	1200
4.	Hired bullock labour	4,500	12	Depreciation on buildings	850
5.	Land revenue	600	13	Other expenses	1600
6.	Maintenance of machinery	4,000	14	Int. on intermediate and long term loans	1000
7.	Equipment depreciation	1,500	15	Livestock depreciation	1000
8.	Fertilizer purchased	2,000			

Ex. No.: 14 **Date:**	**Estimation of Break – Even Analysis.**

Farmers have to decide whether to hire a machine or own a machine to perform a farm operation. A minimum level of work is necessary to justify the purchase of a machine. Break- even analysis is a method used to estimate the minimum level of work the machinery has to perform to justify its purchase. At the breakeven point (BEP) there is no profit or loss.

Procedure to estimating the BEP.

1. Estimate the annual fixed cost; 2. Estimate the running cost/hour
3. Find out the custom hiring charges for the machine.

$$\text{BEP} = \frac{Total\ annual\ fixed\ cost}{Custom\ hire\ charges\ per\ hour - Running\ cost\ per\ hour}$$

Problem: From the data given, find out the BEP for the power sprayer. The prevailing custom hiring charges for the power sprayer is Rs 50/tank. Workout the cost of spraying one ha of Chillies with power sprayer. The total number of spray liquid given 10 tanks and the average time taken/ spraying is 2 hours. Four labour hours are required/ spraying and the cost of labour/hour is Rs 30. Cost of power sprayer is Rs 13000 with the useful life period of 10 years (2500 hrs). the salvage value is Rs.2500. The fuel requirement is one liter petrol /hr and the lubricating oil of 25 ml/lit of petrol. The selling price of petrol is Rs 73 and for lubricating oil is Rs 250 per liter.

Assignments:

A. Work out the Break - Even Point for Power tiller: Given the cost of maintenance of power tiller, find the maintenance cost per acres of 15 acre farm. Cost of the power tiller is Rs.80,000/-. The interest on fixed capital is 12%. Annual repair cost is Rs.1,000, depreciation is 10% fuel and lubrication costs Rs.9000, annual taxes Rs. 1,000/- and insurance premium Rs.1,000/-. Find the maintenance cost of power tiller per acre.

B. *Work out the Break - Even Point for the thresher cum winnower.*

The thresher cum winnower was purchased at a cost of Rs. 1,00,000/-. Assume the interest on fixed capital as 12% and depreciation as 10%. The annual maintenance charge is Rs.1,000/-. The owner has employed 6 unskilled labourers @ Rs.50 per day and one operator @ Rs.100 per day. The machine will consume electricity @8 units/hour. The electricity charge is @ Rs.3 per unit. The output of the machine is 10 quintals of paddy / hour. The custom hire charges are Rs.12 per quintal.Find out the break even point of use of the threshers that would suggest the minimum quantity pfpaddy to be threshed to justify purchase of the thresher cum winnower

Ex. No.: 15 Date:	Graphical Solution to Linear Programming Problem

Linear Programming: George Dantzing (1947) developed the simplex method for optimal transport of ammunition quickly with minimum cost. Linear programming is a mathematical method of analysis, which finds the "best" or optimal combination of business activities to meet a certain objective. Three components are needed to solve a problem with linear programming technique. They are: (1) a desire to maximize or minimize some objective, (2) a set of activities or processes availableto accomplish this objective and (3) a set of constraints or restrictions that limit one's ability to achieve this objective.

Programming implies planning of activities in a manner that achieves some optimal result with restricted resources.

Definition of L.P.

Linear programming is defined as the optimization (Minimization or maximization) of a linear function subject to specific linear inequalities or equalities.

$$Max\ Z \sum_{j=1}^{n} C_j X_j$$

$$st$$

$$\sum_{j=1}^{n} aij < bi \qquad \textbf{i=1 to m; j=1to n}$$

X_j>= 0

cj = Net income from jth activity xj = Level of jth activity

aij = Amount of ith resource required for jth activity

bi = Amount of ith resource available.

1) ***Basic assumptions of Linear Programming***

i) Proportionality or linearity: Linear relationship exists between activity and resource. For example, if one acre requires 30 man days, 100 Kgs of nitrogen and Rs.60 of other variable expenses to produce 20 quintals of maize output, then 10 acres of maize would require exactly 10 times of each resource to produce 200 quintals of output.

ii) Additivity: The total amount of resources used by several enterprises on the farm must be equal to the sum of resources used by each individual enterprise. Hence no interaction is possible. The same is true for the products also.

iii) Divisibility: Fractions can be used and enterprises can be produced in fractional units. Resources and products are infinitely divisible.

iv) Non-negativity: None of the activity is negative.

v) Finiteness: Number of activities and constraints are finite.

vi) Certainty: Almost all planning techniques assume that resources, supplies, input - output coefficients and prices are known with certainty.

2) *Concepts used in Linear Programming*

i) Solution: A solution refers to any set of activities Xj, j = 1, 2, 3, ..., n, which satisfies a system of inequality constraints. There may be innumerable solutions to a given linear programming problem.

ii) Feasible Solution: Any solution to a linear programming problem is said to be feasible, if none of the Xj is negative. How when non-negativity constraint is there in the model.

iii) Infeasible Solution: It refers to a solution, where some of the variables, Xjs, appear at a negative level.

iv) Optimum Solution: One of the feasible solutions is optimum, provided a feasible solution exists. Such a feasible solution, which optimizes the objective function, is called an optimum solution. The set of Xj in this case satisfies the set of constraints and non-negativity restrictions and also maximizes the objective function.

v) Unbounded Solution: Many a time, faulty formulation of a linear programming problem may result in an arbitrarily large value of the objective function and the problem has no finite maximum value of profit. It represents a case of unbounded solution to a linear programming problem.

3) Estimation of Optimum Solution using Linear Programming: The estimation of optimal solution using linear programming is given in table 18.5.

(a) Estimation of Optimum Solution using Linear Programming

Particulars	Per Acre of Paddy	Per Acre of Ground-Nut
Income and Expenses		
1. Gross income	2600	2000
2. Total cost	1100	600
3. Net income	1500	1400
Resource Requirements		
1. Acres of crop- land	1	1
2. Hours of labour during harvesting	45	60
3. Rupees of operating capital	1100	600

(b) Estimation of Optimum Solution using Linear Programming

Particulars	**Amount Available**	**Paddy**		**Ground-nut**	
		Per Acre Needs	**Maximum Area (Acres) Required**	**Per Acre Needs**	**Maximum Area (Acres) Required**
1. Maximum land.	4 acres	1	4.00	1	4.00
2. Maximum hours.	225 hours	45	5.00	60	3.75
3.Maximum operating capital.	Rs. 3500	1100	3.18	600	5.83

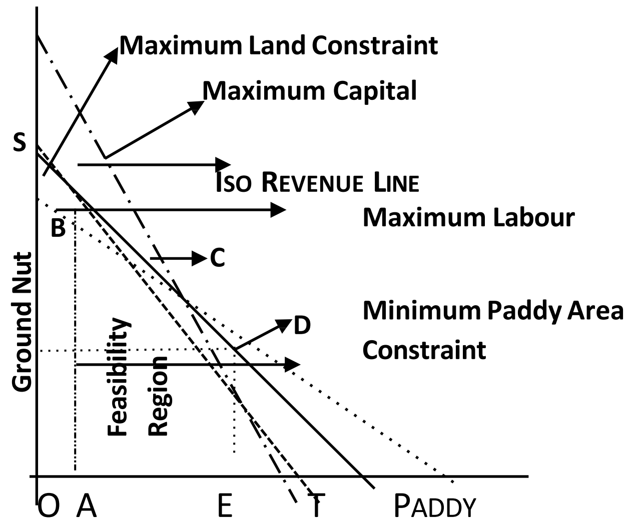


Fig.18.1 Estimation of Optimum Solution using Linear Programming Technique

There is also one additional restriction the farmer wants to incorporate into the analysis. He wants a farm plan that has at least 0.7 acres of paddy. The line that connects points A, B, C, D and E in the figure 18.1 defines an area which contains all numerous combinations of paddy and groundnut that can be produced on this farm. This region is called the feasible region of production. At any point outside this line, the farmer could not produce that combination of paddy or groundnut without isolating any one of the constraints.

In order to complete the graphic analysis, it is necessary to find out the optimal combination of paddy and groundnut that maximizes the net return to the fixed resources of land, labour and operating capital and minimum acreage requirements. This is done by defining a line that will give a constant amount of net revenue, given different acreage combinations of paddy and groundnut. The slope of the iso revenue line is calculated by the following equation:

$$slope\ of\ the\ isorevenue\ line = \frac{Net\ revenue\ for\ paddy}{Net\ revenue\ for\ groundnut} = \frac{1500}{1400} = 1.071$$

Since the iso revenue line indicates a set of net revenues, it is the farmer's desire to find an iso revenue line as far away from the origin as possible. The farther away the iso revenue line, the greater the net income. In addition, he needs to be concerned that the iso revenue line is within the feasible region of product ion. The iso revenue line S and T fulfils both of these requirements. Thus, the production levels indicated at corner point D achieves the maximum level of net Income.

Table Optimum Solution Using Graphical Method of Linear Programming

Particulars	**Non Optimal Plans**				**Optimal Plan**
	A	**B**	**C**	**E**	**(D)**
1. Acres of Paddy	0.70	0.70	1.00	3.18	2.20
2. Acres of ground nut	0.00	3.23	3.00	0.00	1.80
3. Total net income (Rs)	1050	5565	5700	4770	5820
4. Total crop land used	0.70	3.93	4.00	3.18	4.00
5. Total harvesting labour used	31.5	225	225	143	207
6. Total operating capital used	770	2705	2900	3500	3500

The optimal plan is growing of 2.20 acres of paddy and 1.80 acres of groundnut. It has a total net income of Rs.5620. This plan utilizes all the 4 acres of crop land and Rs.3500 of capital. However, not all labour is used in this plan, with 18 hours being unused (225 - 207). The non-optimal plans like A, B, C and E have lesser net income than that of optimal plan (D).

Assignment: Find the optimal solution using the above data (Use graph sheet)

Ex. No.: 16 Date:	Collection and Analysis of Data on Various Resources in India

Some of the important Natural Resources available in India are:- 1. Water Resources; 2. Forest Resources; and 3. Land Resources.

1. *Water Resources:*

Water, a vital natural resource and precious commodity, is essential for multiplicity of purposes, viz., drinking, agriculture, power generation, transportation and waste disposal. The chief sources of water are rain water, sea water, ground and surface water. The World's total quantum of water is 140 x 10^{16} m^3.

a. Sea Water: About 97% of earth's water supply is in the oceans which is unfit for human consumption or other uses due to high salt contents. Of the remaining 3%, 2.3% is locked in the polar ice caps and hence inaccessible. The remaining 0.7% is available as fresh water.

b. Ground water: Ground water, a gift of nature, is about 210×10^9 m^3 (210 BCM) (0.66%) including recharge through infiltration, seepage and evapotranspiration. Out of this nearly one-third is extracted for irrigation, industrial and domestic use, while most of the water is recycled into rivers. The fresh water accounts ground water accounts 450 BCM, 200 BCM from surface flow and 50 BCM which percolates down to ground water deposits. Total surface water flow in the river basin accounts 185 BCM.

Water consumption in major sectors:

Irrigation:

Agriculture sector is the major consumer (93%) of water in India (Table 2). While in a country like Kuwait, which is water poor, only 4% is used for watering the crops. On a global average, 70% of water withdrawn is used for irrigation.

Table 1 Estimates of water requirements (in Bcm) in India

Water need for	**1974**	**2000**	**2025**
Irrigation	350.0	630.0	770.0
Thermal power generation	11.0	60.0	160.0
Industries	5.5	30.0	120.0
Domestic needs	8.8	26.6	39.0
Livestock management	4.7	7.4	11.0
Total	**380.0**	**754.0**	**1100.0**

2. *Forest Resources*

Today forest may be regarded as any land managed for the diverse purpose of forestry, whether covered with trees, shrubs, climbers, lianes or not.

Uses of forests:

1. Commercial uses:

They produce a large number of products of commercial as well as industrial importance. Some of such valued products are structural timber, charcoal, raw materials for the manufacture of paper, newsprint, panel products, bidi leaves, resins, gums, essential oils and a number of useful medicinal shrubs.

2. ***Ecological uses:***

Most of the ecologically useful plants are in the form of herbs, shrubs, climbers and grasses. Tropical forests are considered as the lungs of the earth and have aptly been called as the life support system. They are the treasure house of food, medicines and commerce. These forests harbour some very primitive species of plants and animals and provide the most stable environment for life and land.

3. ***Regulation of climate:***

Rain forests, the most primitive ecosystem, are universally recognized for regulating the global climate, rainfall and the consequent productivity of land and water.

4. ***Reducing global warming:***

The forest canopy absorbs CO_2 during photosynthesis and acts as a sink for green-house gases.

5. ***Soil conservation:***

A properly stocked forest guards against soil erosion, damage of water sheds, floods and sedimentation.

6. ***Regulation of hydrological cycle:***

Forested watersheds act like giant sponges, absorb rain water, increase humidity by transpiration and regulate hydrological cycle.

7. ***Medicinal value:***

Most of the medicinal plants are found in the under-brush strata of the forest. They contain chemicals such as alkaloids, glycosides, terpenoids, lignans, fatty acids, resins, tannins, gums and many other substances which have specific effects on the human body. For example, Tinospora cordifolia, Vitex trifolia, Serpentina, Eucalyptus, rusa grass, khus, camphor and sandal wood are used in medicines. Quinine, a malaria drug, is obtained from the bark of Cinchona.

8. ***Oils:***

Essential oils, obtained from a variety of forest plants, are used in the manufacture of soaps, cosmetics, pharmaceuticals, confectionery and tobacco flavouring etc.

9. ***Food products:***

Vegetative shrubs, herbs, climbers, ferns, mosses are derived from trees and consist of flowers, fruits, leaves, bark, stem or root. Several forest fruits, flowers and even leaves and roots are eaten. Examples are bel, ber, phalsa, jamun, khirni and tendu. The parts of some plants are used as vegetables and for making pickles. Examples are amla, anar, imli, karaunda, kokam, kachnar etc. Kalazira is the seed of carum carvi and is used as a spice. Shahtoot fruit is eaten or made into a sharbat. Tendu leaves are used as wrappers of tobacco to make bidis.

10. ***Desert vegetation:***

India is gifted with cold desert vegetation of Tibet Plateau. It has been estimated that more than 15000 known floral species are found in India. The North-East region, comprising of Assam, Tripura, Meghalaya etc. is the richest zone. There are more than 6700 endemic species largely found in Himalayas and Western Ghats of Peninsular India.

11. ***Shelter for tribal people:***

The forests play an important role in the life of tribal people living in close proximity of forests because they provide them food, shelter, timber, wood fuel, fruits, meat, medicines, hides, skins and other products of their daily and commercial use. Forests also give shelter to diverse species of plants, wildlife and micro-organisms.

12. *Pollution moderators:*

Forests absorb many toxic gases and can help in keeping the air pure. They also absorb noise and thus help in preventing air and noise pollution.

13. *Aesthetic value:*

Forests also have a great aesthetic value. All people appreciate the natural beauty and tranquility of forests.

Over Exploitation of Forest Resources:

Exploitation of vast potential of forests may be due to the following causes:

1. Commercial Demand:
2. Raw Materials for Industrial Use:
3. Development Projects:
4. Growing Food Demands:
5. Fuel Requirement:

Problems of Deforestation:

Destruction of biotic potential of land leads to deforestation, i.e., forest destruction. The total forest area of the world was estimated to be 7000 million hectares in 1900 which fell down to 2100 million hectares by 2010. This process of deforestation is a serious threat to economy, quality of life and future of the environment in our country.

a. Note that we are still far behind the target of achieving 33% forest area as per National Forest Policy. Despite increasing awareness, deforestation rate continues to increase.

b. Each day about 32300 hectares of forests disappear and another 32300 hectare of forest suffers degradation.

c. During the period 2005-2010, the tropical deforestation rate had increased by 9.5% as compared to 1995's deforestation rates.

d. Primary forests have suffered a loss of 25%.

e. Further, forests are being replaced by plantations with much less biodiversity.

Major Causes of Deforestation:

1. Rapid explosion of human and livestock population.
2. Overgrazing by cattle, indiscriminate felling of trees and over exploitation of land resources.
3. Construction of dams destroy thousands of square kilometres of tropical forests. The process of filling the reservoirs may drown large tracks of forests, displace people and kill wild life.
4. Although dams are intended to provide inexpensive electricity, many of them are economic failures because of lack of environmental planning. Erosion of water shed fills reservoirs with silt and reduces the ultimate output and usefulness of dams.
5. Proliferation of industries, quarrying, irrigation and expansion of agricultural land for farming to meet the growing food demand.

Forest Conservation:

The National Forest Policy of India (1988) recommended that one-third (33%) of our land should be under forest cover. But today, the forest cover has reduced to merely 12%. Per capita forest area available in India is 0.06 hectare as against 0.64 hectare of the world's per capita forest area. We have almost reached a critical state which must be remedied before it is too late for our own survival.

Some conservation strategies have been listed as follows.

1. Conservation of Reserve Forests:

Reserve forests include National Parks, Sanctuaries, Biosphere Reserves and the areas where major water resources are located, viz., the Himalayas, Western and Eastern Ghats. These must be protected and no commercial exploitation should be allowed in these areas.

2. *Production Forestry:*

These are forests on the plains and their productivity can be enhanced by proper management. Generally, fast growing trees (Eucalyptus, Acacia) are grown using modern techniques.

Production of commercial forestry is intended entirely for commercial purposes to meet the needs of the forest based industries. Grazing lands and fallow lands not used for agriculture can be used for raising such plantations.

3. *Social Forestry:*

Social forestry is based on public and common land to produce firewood, fodder, fruits and small timber for rural community. The aim is to reduce pressure on natural forests for these requirements.

4. *Agro Forestry:*

Same land is used for farming and forestry by taungya (growing crops between rows of trees) and jhum (shifting crop and forest cultivation) techniques.

5. *Urban Forestry:*

It aims at growing ornamental and fruit trees along roads, parks or vacant lands.

Land as a Resource:

India has total area of about 329 million hectares. The utilization statistics available are for nearly 92.5% of the total area. About 162 million hectares of land is under agriculture cover. Nearly 5% of the land falls under fallow land. About 46 million hectares is under real forest as shown by satellites. A part of land is not in use.

This waste land includes arid, rocky and sandy deserts. Cities and towns which use much land must grow vertically rather than horizontally. The land is also needed for industry, commerce, transport and recreation. Since total land is a fixed asset, we must make efforts for integrated land use planning.

Land Degradation:

Land is an important component of the life support system. Unfortunately, land has been overused and even abused over the centuries. Due to exploding population, land is used increasingly which poses threats to its productivity.

Reckless use damages soil that results into (i) reduction in quality of wood land, grass land, crop land, (ii) soil erosion, (iii) deforestation, (iv) degradation of water sheds and catchments,

(v) Due to demographic pressures land is under stress. Also due to sprawl in agriculture, industry and urbanization, crop land is degraded and losing fast fertile top soil.

Problems

1 Collect the land use pattern for India and Tamil Nadu in 2000-01 and 2016-17, and calculate the % change in the land use pattern and offer your comments.

2. Collect source wise net irrigated area for India and Tamil Nadu in 2000-01 and 2016-17, and calculate the % change in the land use pattern and offer your comments.