Exercise No. 1

STUDY OF DIFFERENT TYPES OF GREEN HOUSES

There are many types of greenhouses developed for different applications.

I) Types accepted by Govt. of Maharashtra :

GH-I : Partially controlled, open ventilator type cooling is effected through ventilation i.e. difference of temperature gradient inside and outside. Normally ventilated.

GH-2 : Completely controlled, No ventilator, Temperature is controlled with Exhaust fans and cooking pad. For better performance, suitable technical design should be done.

GH-3 : Completely controlled, Double inflated paddy film. To keep tow layers of poly films away from each other, blower and motor should be provided. Provision of Co_2 apparatus, computer, exhaust fans & cooling pads. Greenhouse operations should be automatic.

II) Classification on the basis of shape :

A number of greenhouses on the basis of shape are available.

1. Hoop style
2. Trusted roof
3. Gable frame
4. Circular
5. Quinoset

III) Classification on the basis of Span :

1. Single span, Ground to Ground or Free standing

When only one span is used as described in shape, then they are called as single span structures. Many single span structures can be erected. It permits convenient expansion / contraction of business. Also it permits the production of a different plant materials by maintaining different micro-climate in different units. Flexibility can be seen with this type. No Gutter is required.

2. Multispan structure :

Economy in construction, cooling, heating operations and cultural operations. No flexibility. Different crops can not be grown in one structure. Gutter is required.

IV) Greenhouse type based on Utility :

Classification can be made depending on the4 functions or utilities. Of the different utilities, artificial cooling and heating are more expensive and elaborate. Hence, based on this, they are classified in to two types :

a) Green houses for active heating

b) Green houses for active cooling.

V) Greenhouse type based on Construction :

The type of construction predominantly is influenced by structural material, though the covering material also influence the type. Higher the span, stronger should be the material and more structural members are used to make sturdy tissues. For smaller spans, simple designs like hoops can be followed. So based on construction, greenhouses can be classified as :

a) Wooden framed structure
b) Pipe framed structure
c) Truss framed structure

VI) Greenhouse type based on Covering material :

Covering materials are the important component of the greenouse structure. They have direct influence on greenhouse effect, inside the structure and they alter the air temperature inside. The types of frames and method of fixing also varies with covering material. Hence based on the type of covering material they may be classified as :

a) Glass glazing
b) Fibre glass reinforced plastic (FRP) glazing
    i) Plain sheet
    ii) Corrugated sheet
c) Plastic film
    i) UV stabilized LDPE film
    ii) Silpaulin type sheet
    iii) Net house.

VII) Based on the cost of construction involved:

i) High cost Green House
ii) Medium cost Green House
iii) Low cost Green House

The structural requirements and the cost per unit area for different models of low cost green houses for cultivation of vegetables are detailed below with diagrams to enable an interested entrepreneur to construct a low cost green house on his own accord. However, the local weather conditions and the individual necessity play a major role in the selection of the model.

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Exercise No. 2

STUDY OF GREENHOUSE COVERING AND CONSTRUCTION MATERIAL

Glazing (Covering) materials for greenhouse:

The covering of a greenhouse or any structure with transparent material is known as glazing. The glazing material includes glass, poly film, poly carbonate, FRP, EVA, acrylic, polyester, PVF. Except poly film all other covering materials are rigid panels or sheets. Various factors to be considered while selecting the greenhouse covering material are weight, light transmission, thermal stability, durability to outdoor weathering and resistance to impact. The selection of a covering materials depend up on the purpose for which the greenhouse facility is intended. In temperature regions where high temperature, are required, the glazing material with high light transmission and for Infra-Red absorption must be selected. Also in temperate regions covering material should be selected such that the loss of heat by conduction should be minimum. In selection of covering material another important aspect is the service life of material. For fiberglass reinforced polyester and polycarbonate service life is ranging from 5 – 12 years. Considering all the covering materials polyethylene has the best service life of 2 to 6 month. If polyethylene film is stabilized with UV rays, the life can be extended to 2-3 years.

Radiation properties of covering material :

When a beam of radiation is incident on a material, part of it may be reflected back, a part may be absorbed by the material and remaining portion will be transmitted. Depending upon the material composition and surface properties, the radiation absorptivity, reflectivity and transmissivity values are determined for a given material, the values of three coefficients must add to 1.0 with reference to a particular radiation beam.

A transparent material transmits a large portion of light through it, whereas an opaque material either reflects or absorbs the incident radiation. A translucent material may transmit a large portion of radiation but the transmitted light is diffuse in nature.

Height that is utilized in photosynthesis is termed as photo synthetically active radiation (PAR) and comprises the wavelengths from 400 nm to 700 nm. Transmission of PAR through polyethylene can vary with the brand of and the chemical additives in polyethylene (Table 1.2). Uv-stabilized polyethylene, on average, transmits about 87 per-cents PAR. IR-absorbing polyethylene, which reduces radiant heat loss, transmits about 82 percent of PAR. The amount of light passing through two layers of greenhouse covering is approximately the square of the decimal of the amount passing through one layer. Where 87 percent (0.87) passes through one layer of UV-inhibited polyethylene, only 76 per cent ($0.87)^2$ passes through two layers. PAR transmission through two layers of IR-absorbing polyethylene is 67 per- cent.

Table 1.2 Light Transmission values for various greenhouse covering.

Sr. No	Covering Material	No. of layers	Per cent transmission (PAR)
1	Glass (double-strength flood, 3.2 mm)	1	88
		2	77
2	Glass (low-iron, 3.2 mm)	1	90-92
		2	81-85
3	FRP (clear, 0.640 mm)	1	88
		2	77
4	Polyethylene	1	87
	(4 or 6 mil, 0.10 or 0.15 mm, UV stabilized)	2	76
5	Polyethylene	1	82
	(4 or 6 mil, 0.10 or 0.15 mm, IR-absorbing)	2	67
6	Vinyl, clear	1	91
7	Vinyl, hazy	1	89
8	Polyvinyl fluoride film (4 mil, 0.10 mm)	1	92
9	Acrylic panels (8 or 16 mm)	2	83
10	Polycarbonate panels (6 or 8 mm)	2	79

Selective covering material should do the following for ideal greenhouse:

1. It should absorb the small of UV in the radiation and convert a part of it to fluoresce into visible light.
2. It should transmit the visible light portion of the solar radiation which is utilized in photosynthesis by the plants.
3. Cost of the covering material should be minimum.
4. Should have service life of 10 to 20 years.
5. It should reflect or absorb IR radiations which are not useful to plants.

Degradation of glazing material :

The degradation refers to the loss of light transmissivity of a greenhouse glazing material over a period of time. This is also known as weather ability. The traditional glazing material i.e. glass, retains it's transmissivity over a period of several years. On the other hand, the plastic glazing are generally degraded by the U.V. radiation, temperature, air pollutants and other factors. An ordinary PE film is fast degraded by U.V. radiation, becomes brittle and losses it's strength and utility within a period of 3-4 months. However, incorporation of UV stabilizer while manufacturing the PE film increases the service life if the film to more than two years.

Tedlar film (PVF) maintains their transmissivity for a long time. PVC films are susceptible to dust accumulation FRP sheets losses their transparency fast, within a period of 2-3 years. But the panel surface is covered with thin layer of Tedlar film then the light transmission in checked. A twin wall pc panel may also get adversely affected by UV, but a coating of acrylic minimizes the loss of light. Acrylic thin wall panels resists weather ability to a great extent.

Some of the properties of important glazing materials are illustrated in below table .

Properties of important glazing materials

Glazing Properties	Glass	PE	FRP	Acrylic
1. Cost/sq. ft. (Rs.)	15-20	2.50	15	25
2. Life (years)	15	2-3	2-3	10-15
3. Transmissivity (%)	90	88	65-90	83
4. Weight	Heavy	Light	Medium	Medium
5. Handling	Difficult	Easy	Easy	Easy
6. Manufacturing	Difficult	Easy	Medium	Medium
7. Frame work	Heavy	Light	Light	Medium
8. Recycling	No	Yes	No	No
9. Flexibility	No	Yes	No	No
10. Fitting work	Difficult	Easy	Difficult	Difficult
11.Degradation rate	Slow	Fast	Fast	Slow

Greenhouse construction materials:

Commonly used materials used to build frames for green houses are bamboo, wood, re-enforced concrete, aluminum, steel. The selection of these materials was based on their physical properties and requirements of design. Selection of construction material also depends upon life expectancy and cost of the material. Generally common construction materials used in greenhouse are as wood, Galvanized Iron, Aluminum, Steel, Reinforced cement concrete and plastic.

Wood :

Bamboo and wood are used for the construction of low cost greenhouse. The wood is used for making frames. Generally side posts and columns are made from wood. The frame includes, columns, bottom cord, truss members, purl in, knee bracing, wind bracing fitting members etc. The commonly used woods are pine and cascading, which are strong and less expensive. Wood should be treated for protection from high moisture and termites and painted for better light conditions in the greenhouse. Coal tar is good preservative for underground portion of wood. In pipe framed greenhouses, wooden battens can be used in the frames for filing the glazing material. In tropical areas to form the gable roof of a greenhouse bamboo is often used. Natural decay resistance woods, such as redwood or cypress should be treated, in desert or tropical regions.

Galvanized Iron and steel :

Steel and Galvanized Iron members are generally used in frame works of the greenhouse structure. To protect iron or steel against corrosion they are galvanized. In galvanizing the external surface of iron or steel is coated with a thin layer of zinc. Steel components to be used in greenhouse frames should be hot dipped galvanized to avoid rusting. In hot dip galvanizing process, the cleaned member is dipped in molten zinc which provides a layer of zinc alloy to steel. In cold process called as Electro-galvanising the member is zinc plated. G.I. pies, tubular steel and angle iron are used for side posts, columns and purlins, as the wood is becoming score and more expensive. The common problem of rusting of iron structural members is eliminated with galvanization process and makes structural members rust proof. In general for pipe frames G.I. pipes are used as side posts, columns, cross ties and purlins. For truss frames, flat steel, tubular steel or angle iron is welded together to form a truss consisting of rafters, chords and struts. The angle iron purlins are bolted to each truss running throughout the length of the greenhouse.

Aluminum and Reinforced cement concrete :

Many times frames may be all aluminum or steel or a combination of the both materials. Comparatively Aluminum and hot dipped G.I. are maintenance free. Aluminum and steel must be protected from direct contact with the ground to prevent corrosion. Aluminum or steel must be thoroughly painted with bitumen tar, if there is a danger of any part coming into contact with the ground. Aluminium profile with C shape is also used for fixing the film. Generally foundation is made from R.C.C. Foundation should be strong enough to support the super structure against various forces. Pit or pile foundation is common because columns are widely spaced. The depth of foundation should be at least 60 cm. reaching to hard strata with width of 60 cm. The foundation may be RCC, CC or telescopic. The telescopic foundations are easier and less costly. Greenhouse crop may be grown in soil or without soil. The floor of the greenhouse should have drainage. For soil less cultivation, some times porous concrete floors having the depth of 10 cm. are prepared.

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Exercise No. 3

STUDY OF COOLING SYSTEMS USED IN GREEN HOUSES

A need to cool a greenhouse arises whenever the greenhouse air temperature exceeds the upper limit of the crop tolerance. Failure to bring down the temperature effectively may result in either partial or total crop failure within only a very short period of time. Consideration for appropriate cooling systems is essential because temperatures are on higher side for long period in most of the parts of India. Process of cooling system includes selection of cooling method and its designing. Ventilation is the process of allowing the fresh air to enter into the enclosed area by darning out the air with undesirable properties. In greenhouse context, ventilation is essential for reducing temp, replenishing Co_2 ,and controlling RH .Ventilation requirements GH vary greatly depending upon the crop grown and the season of Production .selection of relevant components of equipment's and provision of controls.

Methods of Greenhouse cooling:

Several methods based on Convection / Forced air movement with/ without the evaporation of water are available for cooling of greenhouses. They are explained below.

Ventilation:

Ventilation is the process of allowing the fresh air to enter into the enclosed area by driving out the air with undesirable properties. In greenhouse context, ventilation is essential for reducing Temperature, replenishing CO_2 and controlling Relative Humidity. Ventilation requirements for Greenhouse vary greatly depending upon the crop grown and the season of the production.

Ventilation with roof and side ventilators:

The top ventilators are provided in the roof and rollable curtain arrangement is made by the four sides. The hot air from greenhouse is removed from top ventilators and it is replaced by ambient air from sides. Top ventilators are having the depth of 0.6 to 1.0 m. whereas; side curtain has the width of 1.5 to 3.0 m depending upon the column height. The ventilation area should be at least 20% of floor area for effective ventilation .Generally, such type of structure is affected structure .The air movement in such structure is affected by temperature difference between inside and outside. The wind has also considerable effect on air movement. The cooling system of naturally ventilated structure can not be designed precisely because temperature difference and wind (velocity & direction) are highly variable. The correct placement of top ventilators and proper greenhouse orientation will have partial control cover temperature inside greenhouse.

Roof shading:

Partial shading is used to reduce the intensity of sunlight in the cropped area. Shading can be done by two methods.

a) Application of white wash: Application of white wash with any white material like distemper or lime over glazing material in comparatively and less expensive method. Such a paint washes off by itself by the rain.
b) Shading screen : It can be used for a part of growing season or a specific level of shade is required .The material may be PP .PE or Polyester with different grades of shade like 20%,25%, 35% ,50%,75%and 90%.

Evaporative cooling :(EC)

The degree of cooling obtained from an evaporative system is directly related to the dry-wet bulb difference that occurs with a given set of climatic condition. Evaporative cooling systems are most effective in areas where a consistently low relative humidity exists. Generally, the period of lowest humidity occurs during the hottest part of the day when the greatest degree of cooling is required and Evaporative cooling is more effective .The relative humidity increases as night temperature declines and little or on cooling is required .

a) Fan and Pad system:

It is adaptable to both large and small greenhouses. In this system, low velocity and large volume fans draw air through wet fibrous pads mounted on the opposite side or end wall of the greenhouse. The outside air is cooled to 3-12^{0}C depending upon sunlight intensity, relative humidity and the amount of shading compound applied.

The pad can be made of different materials viz. gravel, straw, wood fiber, khus, honey comb paper & charcoal. Most of the greenhouse will require about I m of pad height for every 20 m of pad to fan distance. Pad design system should provide at least 6 lit water/min per running meter of the pad system of 1 m height. Due to continuous watering, pads accumulate salts, sag and thus create openings that allow hot air to enter the greenhouse. The efficient pad material is of honey comb cellulose paper but it is very costly.

Placement of exhaust fans also affects the distribution of cooled air. They should not be located more than 9 m part otherwise warm areas will develop. Fans should be placed on the side against the direction prevailing winds. Thermo statistically operated F & P system is desirable for uniform and automatic control of temperature. Humidistat may be installed to avoid excess humidity. EC is F & P system for existing greenhouses.

b) High pressure mist system:

Water is sprayed into the air above the plants at pressure of 35-70 kg.cm^2 from low capacity nozzles (1.9 to 2.8 H4).A fine mist fills the greenhouse atmosphere ,cooling the air as it evaporates. Although most of the mist evaporates before reaching the plant level, some of the water settles on the foliage where it reduces leaf temperature .Temperature difference of 5-14^0 C can be obtained between high pressure mist and fan cooled greenhouses. It is more effective during the warmest part of the day.

c) Low pressure mist system:

Misting with water pressure less than $7 kg/cm^2$ have achieved air temperature 5^0C cooler in a greenhouse compared to natural ventilation. The water droplets from a low pressure misting system are quite large and do not evaporate quickly. Leaching of nutrients from soil is a serious drawback in using this.

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Exercise No 4

STUDY OF INSTRUMENTS FOR GREENHOUSE

Various instruments are used for measuring environmental parameters in Greenhouse. These parameters are :

1. Temperature. 2. Solar intensity 3. Humidity 4. Leaf area index
5. Photosynthesis rate etc.

Instruments for temperature measurement:

1.Thermometers :

Types: **A) Liquid in glass thermometers** (eg. Hg. Alcohol coloured with dye)

Range-Minimum 37.5°C for pentane.

Highest 340°C Hg upto 560°C by filling space above Hg with CO_2/N_2 at High pressure

B) Bimetatic Thermometers : In this, the unequal expansion of two dissimilar metals, that have been founded together into narrow strip and coiled, is used to move a pointer round a dial.

C) Gas Thermometer : It is more accurate than liquid-in-gas thermometers, it measures the variation in pressure of gas kept at constant volume.

D) Resistant Thermometer : It is based on the change in resistance of the conductor or semi-conductors with the temp. range. Platinum, nickel and copper are the metals most commonly used in resistance thermometers.

E) Thermister : It is a thermally sensitive variable resister made of ceramic like semi-conducting material. They exist in small thin disc/thin chip/Wafer/large rod. The oxides of Cu, Mn, Ni, Co. Li are blended in suitable proportion and impressed into desired shapes from powders and heat treated to recrysatlize them, resulting in a desired ceramic body with the required resistance temperature characteristics. These are extremely useful for dynamic temp. measurements. It's operating range is 100 ^{0}C to 300 ^{0}C with accuracy of $\pm$ 0.01 ^{0}C.

F) Thermocouple : It is also called as *thermo-electric sensor.* Two wires of different metals twisted and brazed or held together normally from copper and Constantine. The magnitude of thermo-electric motive force (e.m.f.) is related to the temp. difference. Which is measured by a mill voltmeter or can be connected to temperature indicator.

G) Digital Electronic Temperature Indicator :

It directly display the temperature measured with the help of thermocouples and are available in multi-channels so that more than one reading can be recorded for different locations (inside/outside etc.) One end of the thermocouple is placed at location and other end is connected to the digital electronic temp. indicator which is calibrated to measure the direct reading of temperature.

2. **Radiation measuring instruments :**

   Instruments for measuring solar radiation are basically of two types. The accepted terms of these are as follows :-

   A) Pyrheliometer – An instrument using a collimated detector for measuring solar radiation from the sun and from the small portion of the sky around the sun (i.e. beam radiation).
   B) Pyranometer – An instrument for measuring total hemispherical solar (beam + radiation) radiation usually on a horizontal surface. If shaded from the beam radiation by a shade ring or disc a pyronometer measures diffuse radiation.
   C) In addition, the terms, solarimeter and actinometer can be used. Soloarimeter can be interpreated to mean the same as pyranometer where as actinometer usually refers to a pyrheliometric instrument.

3. **Sunshine Recorder :**

It is used for measuring the duration, in hour of bright sunshine during the course of the day.

4. **Photosynthesis Analyser** :

Portable Photosynthesis System : This system extends the boundaries of gas exchange research by providing a portable instruments. It makes rapid simultaneous measurements of photosynthesis rates and stomatal conductance with typical CO_2 depletion of only 1 to 100 ppm and very small RH changes the measurements are made very near ambient conditions.

5. **Leaf Area Index (LAI) :**

Measurement the amount of foliage and its distribution is fundamental to radiation penetration. Direct measurements of canopy structure are tedious and labour intensive in small canopies and nearly impossible in large forest canopies. The instrument used to measure leaf index is LAI-2000.

6. **Measurement of Humidity :**

   The amount of water (vapour) content in the atmosphere (Green house)i.e. humidity is an important parameter in the growth of the GH. Plants.

   Absolute Humidity – It is defined as the mass of water vapour present in unit volume of moist air (gm/m^3).

   Relative Humidity (RH) – The ration between actual water vapour content of air and the amount of vapour the air could hold at saturation at the same temp. expressed as a percentage. The R.H. is measured with the help of hygrometer.

$$RH = \frac{P}{Ps} \; 100 \text{ at same temp.}$$

7. Measurement of pH :

It indicates the acidity and alkalinity of the soil.

8. Data logger :

It is an instrument which can measure the various parameters simultaneously. It is equipped with different probes required for different parameters. The output is displaced on computer monitor or separate display unit.

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Exercise No. 5

STUDY OF IRRIGATION SYSTEM USED IN GREENHOUSE

A well-designed irrigation system will supply the precise amount of water needed each day throughout the year. The quantity of water needed would depend on the growing area, the crop, weather conditions, the time of year and whether the heating or ventilation system is operating. Water needs are also dependent on the type of soil or soil mix and the size and type of the container or bed .Watering in the greenhouse most frequently accounts for loss in crop quality. Though the operation appears to be the simple, proper decision should be taken on how, when and what quantity to be give to the plants after continuous inspection and assessment. Since under watering (less frequent) and over watering (more frequent) will be injurious to the crops, the rules of water application systems, such as hand watering. Perimeter watering, overhead sprinklers, boom watering and drip irrigation which are currently in use will be discussed in this chapter.

1. Rules of Watering

The following are the three important rules of application of irrigation water.

Rule 1: ***Use a well-drained substrate with good structure***

If the root substrate is not well drained and aerated, proper watering cannot be achieved. Hence substrates with ample moisture retention along with good aeration is indispensable for proper growth of the plants. The desired combination of coarse texture and highly stable structure can be obtained from the formulated substrates and not from field soil alone.

Rule 2: ***Water thoroughly each time***

Partial watering of the substrates should be avoided; the supplied water should flow from the bottom in case of containers, and the root zone is wetted thoroughly in case of beds. As a rule, 10 to 15% excess of water is supplied. In general, the water requirements for soil based substrates is at a rate of 20 I/m^2 of bench, 0.3 to 0.35 litres per 16.5 cm (6.5 in) diameter pot.

Rule 3: ***Water just before initial moisture stress occurs***

Since overmastering reduces the aeration and root development, water should be applied just before the plant enters the early symptoms of water stress. The foliar symptoms, such as texture, colour and turgidity can be used to determine the moisture stresses, colour , feel and weight of the substrates are used for assessment.

2. Hand Watering

The most traditional method of irrigation is hand watering and in present days is uneconomical. Growers can afford hand watering only where a crop is still at a high density, such as in seed beds or when they are watered at a few selected post or areas that have dried sooner than others. In all cases, the labour saved will pay for the automatic system in less than one year. It soon will become apparent that this cost is too high. In addition to this deterrent to hand watering, here is a great risk of applying too little water or of waiting too long between watering. Hand watering requires considerable time and is very boring. It is usually performed by inexperienced employees, who may be tempted to speed up the job or put it off to another time. Automatic watering is rapid and easy and is performed by the grower himself. Where hand watering is practiced, water breaks should be used on the end of the hose. Such a device breaks the force of the water, permitting a higher flow rate without washing the root substrate out of the bench or pot. It also lessens the risk of disrupting the structure of the substrate surface.

3. Perimeter Watering

Perimeter watering system can be used for crop production in benches or beds. A typical system consists of a plastic pipe around the perimeter of a bench with nozzles that spray water over the substrate surface below the foliage (Fig.14.1).

Either polyethylene or PVC pipe can be used. While PVC pipe has the advantage of being very stationary, polyethylene pipe tends to roll if it is not anchored firmly to side of the bench. This causes nozzles are rise or fall from proper orientation to the substrate to put out a spray arc of 180^0, 90^0 or 45^0. Regardless of the types of nozzles used. They are staggered across the benches so that each nozzles projects out between two other nozzles on the opposite side. Perimeter watering systems with 180^0 nozzles require one water valve for benches up to 30.5m (100ft), in length. For benches over 30.5m (100 ft) water main should be installed and up to 61.0m (200 ft), a water main should be installed on either side, one to serve each half of the bench. This system applies 1.25 I/min/m of pipe .Where 180^0 and 90^0 or 45^0 nozzles are alternated; the length of a bench serviced by one water valve should not exceed 23 m (75 ft).

4. Overhead Sprinklers

While the foliage on the majority of corps should be kept dry for disease control purposes, a few crops do tolerate wet foliage. These few crops can most easily and cheaply be irrigated from overhead. Bedding plants, azalea liners, and some green plants are crops commonly watered from overhead (Fig.14.2). A pipe is installed along the middle of a bed .Riser pipes are installed periodically to a height well above the final height of corp. A total height of 0.6 m (2 ft) is sufficient for bedding plants flats and 1.8 m(6 ft) for fresh flowers. A nozzle is installed at the top of the each riser. Nozzles vary from those that throw a 360^0 pattern continuously to types that would otherwise fall on the ground between post and is wasted. Each tray is square and meets the adjacent tray. In this way intercepted .Each tray has a depression to accommodate the pot and is then angled upward from the pot toward the tray perimeter. The trays also have drain holes, which allow drainage of excess water and store certain quantity, which is subsequently absorbed by the substrate.

5. Boom Watering

Boom watering can function ether as open or a closed system, and is used often for the production of seedlings grown in plug trays .Plug trays are plastic trays that have width and length dimensions of approximately 30x61 cm (12x24 in), a depth of 13 to 38 mm (0.5 to 1.5 in), and contain about 100 to 800 cells. Each seedling grows in its own individual cell. Precision of watering is extremely important during the 2 to 8 week production time of plug seedlings. A boom watering system generally consists of a water pipe boom that extends from one side of a greenhouse day to the other. The pipe is fitted with nozzles that can spray either water or fertilizer solution down onto the crop. The boom is attached at its center point to a carriage that rides along rails, often suspended above the center walk of the greenhouse bay. In this way, the boom can pass from one end of the bay to the other. The boom is propelled by and electrical motor. The quantity of water delivered per unit area of plants is adjusted by the speed at which the boom travels.

6. Drip Irrigation

Drip irrigation, often referred to as trickle irrigation, consists of laying plastic tubes of small diameter on the surface or subsurface of the field or greenhouse beside or beneath the plants. Water is delivered to the plants at frequent intervals through small holes or emitters located along the tube. Drip irrigation systems are commonly used in combination with protected agriculture, as an integral and essential part of the comprehensive design. When using plastic mulches, row covers, or greenhouses, drip irrigation is the only means of applying uniform water and fertilizer to the plants. Drip irrigation provides maximum control over environmental variability; it assures optimum production with minimal uses of water, while conserving soil and fertilizer nutrients; and control over environmental variability; it assures optimum production with minimal uses of water, fertilizer, labour and machinery costs .Drip irrigation is the best mesans of water conservation. In general, the application efficiency is 90 to 95 % compared with sprinkler at 70% and furrow irrigation at 60 to 80%, depending on soil type, level of field and how water is applied to the furrows. Drip irrigation is not only recommended for protected agriculture but also for open field crop production, especially in arid and semi-arid regions of the world.

Drip irrigation is replacing surface irrigation where water is scarce or expensive, when the soil is too porous or too porous or too impervious for gravity irrigation, land leveling is impossible or very costly, water quality is poor, the climate is too windy for sprinkler irrigation, and where trained irrigation labor is not available or is expensive .In drip irrigation weed growth is reduced ,since irrigation water is applied directly to the plant row and not to the entire field as with sprinkler,furrow,or flood irrigation. Placing the water in the plant row increases the fertilizer efficiency since it is injected into the irrigation water and applied directly to the root zone. Plant foliage diseases may be reduced since the foliage is not wetted during irrigation. One of the disadvantages of drip irrigation is the initial cost of equipment per acre, which may be higher than other systems of irrigation .However; these costs must be evaluated through comparison with the expense of land preparation and maintenance often required by surface irrigation.

Basic equipment for drip irrigation consists of a pump, a main line, delivery pipes, manifold, and drip tape laterals or emitters (fig. 14.3). The head between the pump and the pipeline network usually consists of control valves, couplings, filters, time clocks fertilizer injectors, pressure regulators, flow meters, and gauges. Since the water passes through very small outlets in emitters, it is an absolute necessity that it should be screened, filtered, or both, before it is distributed in the pipe system is influenced by the topography of the land and the cost of various system configurations. Design considerations should also include the relationship between the various system components and the farm equipment required to plant, cultivate, maintain and harvest the crop.

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Exercise No. 6

COST ESTIMATION OF POLY HOUSES FOR 560 SQ.M.

Type : Naturally ventilated structure, open vent type (GH-1 type)

Given Data : Area – 560 sq.m (20 X 28 m)
Bay size : 6 x 3m, 6 x 4m, 7 x 4m, 8 x 4m,
Vent opening – 0.8 to 1.0 m
Height – Ridge height – 6 m
Height under Gutter – 3.5m.
Polyfilm – UV stabilized, 200 micron.

Cost estimate

S N	Item	Quantity	Rate	Unit	Amount
1.	Columns – 2", 4m length				
2.	Bottom cord – 2", 8m length				
3.	Top cords – 2", (5.3 + 4.5M0 length				
4.	Truss members, 1" (length to be calculated)				
5.	Purlins, 1",				
6.	Curtain pipe, ½ " GI				
7.	**Fitting material**				
	i) Wooden button or				
	ii) Plastic gripper or				
	iii) Aluminium profile				
8.	Polyfilm				
9.	Telescopic foundations (on No. basis)				
10.	Doors				
	Sub Total				
	Add 15% for fabrication & erection				
	Add 3% for contingencies				
	Total				

Ex. Prepare an estimate of Naturally ventilated structure.
GH-1 type for following data

1. Size - 20 x 28 m
2. Bay size – 8 x 4 m.
3. Height under Gutter 3 m.
4. Depth of ventilation – 0.75 m
5. Ridge height – 4.8 m
6. Number of Gutter – One
7. Type of steel material – G.I.

Estimation of cost of GH-1 Polyhouse (size 32 x 16 m)

Sr. No.	Items with specifications	Qty	Rate Rs.	Unit	Amount Rs.
1.	**G I for coloumn, 50 mm diameter 3.3 length** 9 No.s x 3 rows = 27	90	139 / m	M	12510.00
2.	**G I for bottom cord, 50 mm, 8 mm length, 9 No.s x 2 = 18**	144	116 / m	M	16704.00
3.	**G I for top cords, 50 mm (4.7 + 4.2) = 8.9 m, 9 No.s x 2 times = 18 m**	160	116 / m	M	18560.00
4.	**G I for central pipe, 50 mm, 1.8 m length, 9 No.s x 2 times = 18**	33	116 / m	M	3828.00
5.	**Truss member, 25 mm,** 0.9 + 2.2 + 2 + 0.6 = 5.7 m, 9 No.s x 2 rows = 18 No.s.	103	60 / m	M	6180.00
6.	**Film fixing angle, 40 x 40 x 5 mm 4 times x 2 x 32 m = 256 m** Apron 32 + 32 + 16 + 16 =96m Curtain 32 + 32 + 16 + 16 = 96 m For Gable Total 99 m	547	45 / m	M	24615.00
7.	**Length of gripper & batten** @ Gripper @ Rs.20 /m & batten @ Rs. 5/ m	547	25 / m	M	13675.00
8.	G I Sheet for gutter 2 mm 0.5 x 33	16.5	1000/m^2	Sq. m.	16500.00
9.	G I pipe for curtain 15 mm	100	12	M	1200.00
10.	Polyfilm, µv stabilized 200 µ 4.7 + 0.3 = 4.5 m width 33 m length. Two pieces 4.2 + 0.3 = 4.5 m width 33 m length two pieces Curtain 1.8 + 0.3 + 0.3 = 2.4 m width 33 m x 2 17 m x 2 Apron – 33 x 2 x 2 1.2 + 0.5 + 0.3 = 2 m, 17x2x2 Gables 17 m x 2 m x 2 sides	330 159 82 132 68 68 -------- **1136**	24/ sq.m.	Sq.m. m^2	27264.00
Sr.	**Items with specifications**	**Qty**	**Rate**	**Unit**	**Amount**

No.			**Rs.**		**Rs.**
11.	Doors Two No.s. 2 m x 1.2 m	Two	250	Nos.	500.00

12.	Foundation Telescopic 9 Nos. x 3 rows **Total**	27	300/-	N0.	8100.00 ------------- **134786.00**
13.	Fabrication and Erection Labour 15% of item 1 to 12				**20818.00**
14.	Contingencies 3% of item 1 to 12 **Total** **Cost per sq. m.**				**4044.00** **159648.00** **4312.00**

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Exercise no. 7
VISIT TO COMMERCIAL GREENHOUSE

A report of visit to greenhouse

Proforma :

1) Site of Greenhouse :i) Size of Green House: ------- X --------- m.

ii) Water Source:

iii) Crop and Variety:

iv) Soil or media Used :

v) Temperature:

vi) Humidity:

2) Type of Greenhouse : i) G. H. 1 / G. H. 2 / G. H. 3

ii) G. H. -Class based on Shape-

iii) G. H. -Class based on Utility-

iv) G. H. -Class based on Covering Material

v) G. H. -Class based on Construction

3) Covering material used in greenhouse / Shade House :

i) Material Used –

ii) Thickness –

iii) UV Stabilized : yes / No

iv) Percent Open Area for shadenet: --------- %

4) Instruments used in Greenhouse :List of Instruments and their use

5) Irrigation method used in Greenhouse :

I) Drip Irrigation System:- a) Type- Online / Inline

b) Size of Main/ Sub-Main and Lateral: -----,

----- and ----mm

c) Discharge of Emitters: ------------ LPH

d) Lateral spacing: -----------m, Emitter

Spacing:- ------------m

e) Type of Filter:- sand/ Screen/ Disc/

Hydro-Cyclone----------------

f) Filter Flow Rate ------------cu.m / hr.

6) Cooling System : Fan Pad / High Pressure Mist System/ Low Pressure Mist System

7) Material of Construction of Greenhouse :a) Structure :Wooden Frame / Pipe frame / Truss Frame

:

b) Pipe Size :-

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Exercise no. 8
DETERMINATION OF MOISTURE CONTENT OF VARIOUS GRAINS BY OVEN METHOD

1. Determination of Moisture Content by Air Oven method (Direct Method**):**
Equipment :

a) Moisture dishes :

For moisture measurement, the moisture dishes should be made of heavy gauge aluminium metal sheet. The dishes should have tight covers. Some number should be marked on the dish and its cover. Before use, the moisture dishes should be dried in an oven for one.

b) Desicator :

The desicator should be properly air tight and have active absorbent inside.

c) Grinding mill :

The mill should be used for grinding the sample without undue exposure to the atmosphere and without appreciable heating so as to avoid possible gain or loss of moisture. Screen size of 18 mesh should be used during grinding.

d) Oven :

Convective type ovens are mostly used for moisture determination. These are sufficiently heat resistant. These ovens maintain predetermined temperature. The oven should have arrangement for proper air circulation, transferable perforated trays and a suitable thermometer, sensitive enough to show 0.5^{O}C temperature difference. The oven should be run for few hours prior to their use for determination of moisture.

e) Balance :

An analytical balance should be used to determine the moisture content of product correctly. The balance should be sensitive enough to weight upto 0.01 grams.

Procedure :
a) Direct Determination for unground sample :

In this method 25 to 30 grms of unground representative samples of grains are taken and placed in an air over at 100^{O}C temp. The samples are kept in it for 72 to 96 hours. After words, the sample are taken out from oven placed in a desicator to cool down to room temp. Moisture content of sample is measured based on drop in weight from initial weight of sample.

b) For samples requiring grinding for moisture determination :

When the moisture content of grain is upto 13 %, 2-3 grams representative ground samples of grain are placed in an oven. The temp. of the oven is set at 130^{O}C and the samples are kept in oven for 1-2 hours. Afterwords, the sample are taken out and placed in a desiccator to cool down. The drop in the weight of grain is measured based on it's initial weight.

For above two methods of air over following formula is used –

Moisture content per cent wet basis is calculate as :

$$M_{wb} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

Where,

M_1 = Weight of dish and it's cover in gram

M_2 = Weight of dish, it's cover and content in gram

M_3 = Weight of dish, it's cover and content in gram after drying

c) Two Stage Determination :

This procedure is used when sample, after oven trails, shows more than 13% of moisture. Fill two or more tared moisture dishes nearly full with the unground working sample, the moisture content of which is to be determined.

First stage :

Weigh each covered dish including its contents and transfer the uncovered dish to an air oven at a temperature of 130^{o}C for 5-10 minutes, or place the uncovered dished on top of heated oven for 14-16 hours. The length of this preliminary drying period may depend upon the type of grains and on the amount of moisture, it may be necessary to remove. In all cases, except for soybeans and paddy, the moisture content should be reduced to 15% (10% in case of soybeans and 13% in case of paddy) in this first stage.

Second Stage :

1. Spread the partly-dried seed in an open tray and leave for 2 hours.
2. Transfer the material to the container in which it was oven dried and weigh to an accuracy of 10 mg.
3. Calculate the loss of moisture as in (a) above, by direct method.
4. Now, grind separately the two partly-dried working samples and on the ground material from each make a single moisture determination as in (b) above and calculate the loss of moisture.

For above two stage methods of Air Oven following formula is used

Moisture content per cent wet basis is calculated as :

$$Mwb = \frac{S_1 + S_2}{W_2 - W_1} \times 100$$

Where,

S_1 = Moisture loss is stage I in gram

S_2 = Moisture loss in stage II in gram

W_1 = Empty weight of dish in gram
W_2 = Weight of dish with sample in gram

Precautions :

1. Blades of grinding machine should always be kept sharp as blade tend to give higher value of moisture than those obtained with the dull blade.
2. Minimum possible pressure should be used in feeding the sample through the mill.
3. All weighings should be made to an accuracy of 1 mg.
4. Both the moisture dish and its cover should be identified by the same number.
5. Before using a moisture dish, it should be washed with a mild soap, scoured with a fine grade of steel wool, dried with a cloth for one hour at 130^{O}C or by an equivalent drying procedure, cooled in desicator, and the tare weight obtained.

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Exercise no. 9

DETERMINATION OF MOISTURE CONTENT OF VARIOUS GRAINS BY UNIVERSAL MOISTURE METER

Determination of Moisture Content by Universal moisture meter (Indirect Method)

Material required :

1) Universal moisture meter.
2) Material (Grains) sample.

Principle of operation :

In the operation of Universal moisture meter the electrical component records the resistance of a sample of a specified weight or volume that has been compressed to predetermine thickness. The resistance of the sample varies with the amount of moisture content and the temperature. Thermometer is set in the unit together with a correlator dial.

Constructional features : Moisture meters have the following essential parts :

A) **Mechanical parts :**

The mechanical parts of universal moisture meter consist of a compression unit for compressing test material placed in an insulated test cup, under a fixed steel plunger.

In order to compress the test material, the test cup is slowly raised upward against the fixed steel plunger by a bevel gears. The necessary pressure applied to the test material compresses it to the desired thickness setting. The thickness is accurately measured by a system of two correlated scales which comprises of a vertically mounted scale coupled with a micrometer scale.

B) Electronic unit :

The complete electronic circuit is a housed in a specially designed metallic box fitted to the metallic base of the instrument. The battery or battery eliminating device is also housed inside the box. An electrical meter, correlator dial and the necessary knobs, switches etc. are fitted to the top panel of this electronic unit.

Procedure :

1. Obtaining the sample : Be sure that sample to be tested is taken from representative sample of the entire lot and is mixed thoroughly. A measuring cup of the proper volume (A,B, or C) is filled with test material upto its brim.
2. Placing the test cup : Place the test cup containing the sample on the lower terminal plate (behind the thermometer) and lock in place by turning the handle to the left. Always wipe out the cup and upper plunger after each test.
3. Compress the sample : To compress the sample to proper thickness, refer to the thickness setting table for correct compression thickness of material being compressed, Remove the ratchet from the instrument and turn the handwheel clockwise until test cup is compressed against upper plunger. Replace the ratchet and continue to compress the sample until the pointer lies opposite the desired number on the vertical scale and micrometer wheel shows the correct number opposite zero line on the tester body.
4. Temperature reading : Allow sample to remain compressed for several seconds then take a reading on the built in thermometer : Under extreme conditions as in high moisture maize the best rule is to allow the sample to remain compressed until a steady electrical reading can be obtained. The maximum time is five minutes. The thermometer which is an integral part of the lower terminal plate continually indicates the temperature of the entire instrument and not the temperature of sample only. By high pressure you are forcing the sample to agree with the temperature of the instrument so thermometer reading will not fluctuate widely.
5. Obtaining the electrical meter reading : The electrical component consist of a true Ohm-Meter. On the meter there are two scales and one needle. Set the switch on the outer scale and if the needle runs off the scale represents the moisture content is high. Set the scale on inner scale and obtain a reading.
6. Obtaining the moisture percentage reading : On the correlated dial the line of the meter reading viewed through the opening in the disk with the temperature reading. Then read the moisture percentage on the outer scale opposite the arrow.
7. To release pressure and remove the sample : Reverse the ratchet and lower the sample cup until pressure is released. Remove the ratchet and turn hand wheel in counter clockwise direction until test cup is fully lowered. Turn the cup handle to right and leave the cup out. Empty out the sample and be sure to wipe the inside of the cup and bottom of the plunger. Do not scratch inside of the cup.

Application :

Universal moisture meter are best suited for quick and accurate determination of moisture content in percent.

1) Food grains 2) Oats
3) Pulses 4) Water melon seeds.
5) Oil seed 6) Coffee beans
7) Cotton seeds

Thickness Setting Chart

(Food grains)

Sr.No	**Material**	**Sample**	**Thickness**	**Remarks**
1.	Barley	Volume B	0.625′′	Add 1%
2.	Maize	Volume B	0.560′′	
3.	Millet	Volume B	0.500′′	
4.	Sorghum	Volume B	0.675′′	
5.	Wheat	Volume A	0.275′′	
6.	Rice(parboiled)	Volume A	0.325′′	

Pulses

Sr.No.	**Material**	**Sample**	**Thickness**	**Remarks**
1.	Pigeon Pea	Volume C	0.450′′	Add 1.5%
2.	Black gram	Volume A	0.200′′	
3.	Cow Peas	Volume A	0.325′′	Subtract 1%
4.	Gram (Solid)	Volume C	0.500′′	
5.	Gram Dal	Volume C	0.450′′	
6.	Peas	Volume C	0.450′′	
7.	Soybean	Volume B	0.575′′	
8.	Mug	Volume 'A'	0.250′′	Multiply by 0.6
9.	Mug Dal	Volume 'A'	0.300″	Multiply by 0.67

Oil Seeds

Sr.No.	**Material**	**Sample**	**Thickness**	**Remarks**
1.	Ground-nut in shells	25 grams	0.300′′	Multiply by 0.6
2.	Groundnut shelled	26 grams	0.450′′	Multiply by 0.56
3.	Mustered	Volume C	0.475′′	Multiply by 0.6

Exercise no. 10
DETERMINATION OF MOISTURE CONTENT OF VARIOUS GRAINS BY INFRARED MOISTURE METER

INFRARED MOISTURE METER

In this method, grain moisture contend is directly measured by evaporation of water from a sample of grain with an infra-red heating lamp. The instrument consists of a balance, a pan counter balanced by a fixed weight and a variable length of weighing chain. An in infra-red lamp is mounted as an arm above the pan with a provision to change its height. A scale calibrated in percentage moisture content is incorporated in the stem of the interment. At the end of the test, when the balance is zeroed, a direct reading of moisture content is obtained. The sample of grains may be unground, but when ground sample is used, the time needed to evaporate the water is reduced

Precautions

* The temperature and time for moisture removal is maintained properly.
* Clean and dry moisture boxes should be used for experimentation.
* Condensed water should be collected properly and weighed.

Results :

Tabulate the results as follows :

Sr. No.	Moisture measurement method	Sample No. (wet basis)	Moisture content (dry basis)	Moisture content
1.	Infrared moisture meter method	1 2 3		

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Exercise no. 11
DETERMINATION OF PHYSICAL PROPERTIES OF GRAINS

Physical Properties :

The physical properties such as size, shape, surface area, volume, density, porosity, colour and appearance are important in designing a particular equipment or determining the behaviour of the product for its handling.

Various types of cleaning, grading and separation equipment are designed on the basis of physical properties of seeds such as size, shape, specific gravity, surface roughness, colour etc. For designing an air screen grain cleaner, the shape and size of the grain determine the shape and size of screen openings, angle of inclination and vibration amplitude and frequency of screens. The density of the grains decides the size of screening surface. The frontal area and related diameters and density are essential for determination of terminal velocity of the grain. Terminal velocity is necessary to decide about the winnowing velocity of air blast for separation of lighter materials in air screen grain cleaners.

The shape of product is an important parameter which affects conveying characteristics of solid materials by air or water. The shape is also considered in calculation of various cooling and heating loads of food materials.

The frontal area and the related diameters are essential for determination of terminal velocity, Reynold's number and drag coefficient. The density and specific gravity are needed for calculating the thermal diffusivity in heat transfer operations, in determining Reynold's number, in pneumatic and hydraulic handling of the agricultural materials.

The surface characteristics, colour and appearance are exploited for selective separation and storage of fruits and vegetables.

Some of the important physical properties are described below :

Shape and size :

The following parameters may be measured for describing the shape and size of the granular agricultural materials.

(i) Roundness :

It is a measure of the sharpness of the solid material. The most widely accepted methods for determining the roundness of irregular particle are given below :

$$\text{Roundness} = \frac{\text{Largest projected area of the particle when it is in natural rest position, } A_p}{\text{Area of smallest circumscribing circle, } A_c}$$

$$\text{Roundness ratio} = \frac{\text{Radius of curvature, } r_1 \text{ of the sharpest corner}}{\text{Mean radius of the particle, } R}$$

(ii) Sphericity :

Sphericity may be **defined** as the **ratio of the diameter of a sphere of the same volume as that of the particle and the diameter of the smallest circumscribing sphere or generally the largest diameter of the particle.**

This parameter shows the shape character of the particle relative to the sphere having same volume. If D_e is the diameter of a sphere having same volume as that of the particle and D_c is the diameter of the smallest circumscribing sphere, then the sphericity can be expressed as under :

$$\text{Sphericity} = \frac{D_e}{D_c}$$

Density and Specific Gravity :

The density of any material may be expressed as below :

$$\text{Density} = \frac{\text{Weight of the material, kg}}{\text{Volume of the material m}^3}$$

The density and specific gravity values of grains and other commodities are used in design of storage bins and silos, separation of desirable materials from impurities, cleaning and grading, evaluation of the grain maturity, texture and softness of fruits, quality evaluation of the products etc.

Some of the agricultural products having irregular shape, small size and void spaces pose certain problems in measurement of volume and density. The volume of such irregular shaped material is generally determined by displacement method which has been described here.

Determination of volume by Platform scale:

The platform scale is a simple technique which is commonly used for determination of volume of large materials like fruits and vegetables. The weight of material is determined by weighing on the scale in air, thereafter, the material is forced into the water with the help of a rod. The later reading of the scale while the material is submerged minus the weight of container and water is the actual weight of the displaced water. The volume, density and specific gravity of the material are estimated by following formulae.

$$\text{Volume, m}^3 = \frac{\text{Weight of the displaced water, kg}}{\text{Weight density of water, kg/m}^3}$$

$$\text{Weight density kg/m}^3 = \frac{\text{Weight of the material in air , kg}}{\text{Volume of the material, m}^3}$$

$$\text{Specific gravity} = \frac{\text{Weight in air x specific gravity of water}}{\text{Weight of displaced water}}$$

Determination of Specific gravity by Pycnometer method :

The specific gravity bottle or pycnometer and toluene ($C_6H_5CH_3$) are used for determination of specific gravity of granular agricultural materials. The following procedure is used for determination of the specific gravity :

Procedure :

(i) The weight of empty pycnometer and the weight of pycnometer filled with water at 20 ^{0}C are taken.

(ii) The specific gravity of toluene is determined as the ratio of the weight of toluene in the bottle and weight of distilled water in the bottle at same temperature.

$$\text{Specific gravity of toluene} = \frac{\text{Weight in toluene}}{\text{Weight of water}}$$

(iii) The gram sample of grain is placed in the pycnometer and filled with toluene to cover the sample.

(iv) The air is completely exhausted from the bottle by a vacuum pump,.

(v) When there is no air bubble remain the bottle, the bottle is filled with toluene and the temperature is allowed to reach 20 ^{0}C.

(vi) The bottle is weighted and the specific gravity of grain is calculated by following expressions :

$$\text{Specific gravity of grain} = \frac{\text{Specific gravity of toluene x weight of grain}}{\text{Weight of the toluene displaced by the grain}}$$

$$= \frac{\text{Specific gravity of toluene x Weight of grain}}{[\text{ (Wt. of sample) - (Wt. of toluene + sample + bottle) -(Wt. of toluene + bottle) }]}$$

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Exercise No. 12

STUDY OF LSU AND BAFFLE DRYERS

Mechanical drying :

This process utilizes mechanical means for farm products by ventilating natural or heated air through the material to accomplish the removal of excess moisture from it, dryers used for this process are known as mechanical dryers.

Classification : The mechanical dryers are classified as :

1. **Sack dryers**
   a) Batch dryers b) Flat bed dryers
2. **Continuous flow dryers**
   a) Mixing and Non-mixing type
   b) L.S.U. dryer
3. **Tray dryer**
4. **Rotary dryers**
5. **Solar dryers**.

A) BAFFLE DRYERS :

This is a continuous flow mixing type of grain dryer. The main components of the dryers at (i) Receiving bin, (ii) Drying chamber, (iii) Plenum chamber, (iv) Adjustable speed discharge roll and (v) Screw conveyor discharge system. The dryer is made of mild steel sections and mild steel sheets.

Operation :

Grain is fed at the top in receiving bin where from it is allowed to go downward in a zigzag fashion. This design helps in mixing of dried and undried grains. This grain can be recirculated till the desired moisture content is achieved. These dryer uses low air flow rate of 50-95 m^3/min-tonne and high drying temperature of 65^{O}C.

Advantages

1. Uniformly dried product is obtained

Disadvantages

1. Ratio of the volume of plenum to the total volume of the dryer is relatively high.
2. High buildings are required because height is required to get the capacity.
3. High capital investment.

B) LOUISIANA STATE UNIVERSITY DRYER (LSU) :

This is a continuous mixing type of grain dryer. Which is popular in India.

Construction : The LSU dryer consists of following.

1. Drying chamber (Rectangular bin).
2. Air distribution system
3. Air blowing and heating system.

A) Drying chamber

The drying chamber is usually square in shape (1.2m X 1.2m or 1.5m X 1.5m or 1.8m X 1.8m). The height of the chamber varies from 6 to 12m. The square column has two sections:

a) The bottom section which is actual drying chamber and
b) The top section which acts as the holding bin.

The drying chamber contains inverted trough or 'V' shaped channels are called inlet ports. Alternate rows of these port are opened on the blower end and closed on the exhaust end. Hot air enters in the drying chamber through these ports. The other rows of the ports are closed on blower end and are opened on exhaust end. These are called outlet ports as drying air goes out through these ports. These inlet and outlet ports are uniform in size, equal in number and spacing.

2. Air distribution system

The inlet and outlet ports are arranged one below the other in zigzag path, so when grain flow down between these ports, it takes a zigzag path. Hot air enters the inlet ports from blower end. The hot air from these ports flows down through the grain and enters to the outlet ports and goes out. Mixing of hot air and grain occurs in this chamber. The discharge of the grain is regulated by three fluted rolls attached at the bottom.

3. Air blowing and heating system

To provide hot air for drying, fuel is burnt to raise the air temperature. Heat can be supplied directly by the use of gas burner or oil burner or husk fired furnace and indirectly by the use of heat exchanger. Indirect heating is less efficient than direct firing system.

Recommendations :

1. The capacity of the dryer varies from 2 to 12 tonnes of grain.
2. The recommended air temperature is 60^0C
3. The recommended air flow rate is 70 m^3/min/tonne of holding capacity of dryer.
4. The grain temperature during drying should not exceed 40^0C.

Advantages

1. Uniformly dried product can be obtained if the dryer is designed properly.
2. The dryer can be used for different types of grains.

Disadvantages

1. High capital investment.
2. Cost of drying is very high if oil is used as fuel.

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Exercise No. 12

STUDY OF TRAY AND SOLAR DRYERS

A) TRAY DRYERS :

In a tray dryer, many shallow trays are kept one above the other with a gap in between, in the drying chamber. Tray dryer is generally used for drying of vegetables and similar semi-perishables. The trays may or may not have perforated bottom. Perforated trays are used when the plenum chamber is at the bottom of drying chamber. If the heated air is coming from the side of drying chamber, the trays may not have perforated bottom. The gap in between the group of trays permits air ventilation. Products are kept in thin layers in the trays.

B) SOLAR DRYERS :

Solar drying provides higher air temperatures and lower relative humilities than the simple sun drying. It enhances the drying rates and lower final moisture content of dried product.

Principles

Two basic principles are inherent in the operation of solar dryers, firstly the solar heating of air and secondly the removal of moisture from the wet material by the heated air.

Classification : Classification of solar dryers can be made on the following criteria :

1. On degree of exposure the solar dryers are classified as direct and indirect type.
2. The mode of air flow through the dryer, the solar dryers are classified as natural and forced convection dryers.
3. The temperature of the air circulated to the drying chamber

The commonly used solar dryers are grouped as below :

i) Direct dryer with natural convection with combined collector and drying chamber (solar cabinet dryer)

The basic design consists of a rectangular insulated cabinet and covered with a roof of glass or clear plastic. Holes are made through the base and upper parts of the cabinet. The sun rays passes through the roof and is absorbed on the black interior surface which are then heated and warm the air within the cabinet. The warm air rises by natural convection and passes out of the upper out of the upper holes.

ii) Direct dryer with natural convection with separate collector and drying chamber

The solar collector is made by spreading burnt rice husk on level ground. It is covered with plastic sheet on a chamber is a shallow wooden base with either perforated metal or bamboo matting. The drying chamber has removable panels at the back. It is provided with a chimney to provide a column of warm air for increasing the draught or the flow of air. The dryer is successfully used to dry the paddy in monsoon.

iii) Indirect dryer with forced convection with separate collector and drying chamber

In this dryer the roof is used as solar collector. The warm air from roof section is sucked by a blower and delivered to the lower plenum chamber under the drying bin. The warm air is ventilated through the product kept in drying racks and it leaves the room through north facing roof.

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Exercise No. 14

STUDY OF MATERIAL HANDLING EQUIPMENTS (I) BELT CONVEYOR, (II) SCREW CONVEYOR AND (III) BUCKET ELEVATOR

The most common type of mechanical devices for grain handling are :

1) Belt conveyor
2) Screw conveyor
3) Bucket elevator

1. Belt Conveyor

A belt conveyor is an endless belt operating between two pulleys with its load supported on idlers. The belt may be flat for transporting bagged material or 'V' shaped or some other enclosed shape for moving bulk grains. The belt conveyor consist of a belt, drive mechanism, end pulleys, idlers loading and discharge devices.

Characteristics of belt conveyor

1) Belt conveyor have antifriction bearing, therefore these have a high mechanical efficiency.
2) Material carried by belt conveyor lie on the surface of belt so there is no relative motion between the product and belt. This results no damage to material.
3) Belt can be run at higher speeds, so large carrying capacities are possible.
4) Horizontally the material can be transported to longer distance, but there is a limit to carry the material on elevation.
5) Longer service life and low operating costs.

2. Screw Conveyor

Screw conveyor is also known as auger conveyor.

Principle

In a nut and screw, if nut is prevented from rotation and screw is rotating then material can be conveyed. Material behaves by virtue of friction like screw.

Construction

Screw conveyor primarily consists of screw rotating in a stationary trough. Screw may be of various shape depending on the purpose. It may be helical, spiral or cut flight helical spiral, cut and folded flight screw conveyor, ribbon flight. Shafts should be supported at intermediate points and for this intermediate bearings are used. Intermediate openings are kept. Hanger bearing is fitted in between intermediate space of two shafts. Hanger bearing prevents the direct contact between flight and stationary trough. During the pushing of material axial thrust is predominant and to overcome this axial bearings are provided. So both radial and axial thrust are taken by bearings provided V belt is used for motor. Slip coupling is provided to protect the motor from damage.

Operation

Material placed in a trough moves along its length by the rotation of screw which is supported by intermediate hanger bearing. The material may be discharged at the end of trough or along the run through openings in the bottom of trough which are provided with gates that the opened or closed as and when needed by means of rack and pinion arrangement.

Applications

1) Screw conveyors are used to handle finely divided powders, damp, sticky, heavy, viscous materials, hot substance that may be chemically active and granular materials of all types.
2) Useful for moving food products such as powdered milk and peanut butter.
3) Screw conveyor are used for batch or continuous mixing, for feeding where a fairly accuracy is required, and for conventional conveying and elevating jobs particularly where run is short.
4) Ribbon screws are used for wet or sticky substances.
5) Special cut flight and ribbon screws are used for mixing, blending and churning.

Merits and demerits

1) Screw conveyors are very compact and can be easily adopted to conjusted location.
2) Best suited for controlled flow of material in the processing operations.
3) Can also be used as mixer, agitator or stirrer to mix and blend dry or fluid ingredient enroute.
4) Screw conveyors can be effectively seal to prevent dust or flame from escaping and dirt and moisture from entering.
5) They can be jacket to serve as dryer
6) They are not suitable for moving large, lumpy, easily crushed, abrasive packing and sticking material.
7) Needs uniform control feeding. Hence feeder is essential element.
8) Overloads stucks the shaft from rotation or some times completely stop the screw.
9) Power consumptions are very high.
10) Material gets crushed during conveying.
11) Excessive wear of constituent parts takes place.
12) Used for low and medium capacities and for short runs only.

The capacity of screw conveyor is influenced by screw diameter, inclination of screw blade, speed of the blade, shaft diameter and cross section of loading.

The theoretical conveyance capacity of the screw conveyor can be given by the following formula.Capacity (Q)

$Q, m^3/hr = 47.2 (D^2 – d^2) \times p \times n$

Where,

D = Screw diameter, m

d = Shaft diameter, m

p = pitch, m

n = rpm

The power requirement of screw conveyors for horizontal operation may be determined by the following equation -

$$\textbf{Horse Power} = \frac{QLWF}{4500}$$

Where,

Q = Conveyor capacity, m^3/hr

L = Conveyor length, m

W = Bulk material weight kg/m^3

F = Material factor (for paddy 0.4)

3. Bucket Elevators

Bucket elevators may be classed under either belt or chain conveyors or both, since they are special adoptions of these.

Speed of the belt - 2.5 to 4 m/s

Capacity of bucket elevators may vary from 2 to 1000 t/hr. Bucket elevators are classification into two main types (A) Spaced bucket elevators (B) Continuous bucket elevators

A) Types of spaced bucket elevator –

i) Centrifugal discharge elevators

ii) Positive discharge elevators

iii) Marine leg elevators

iv) High speed elevators

B) Types of Continuous bucket elevator –

i) Super capacity bucket elevator

ii) Internal discharge bucket elevators

Construction

The bucket elevator of an endless belt to which small cups are attached.

Main parts of bucket elevators are

i) Elevator head section

ii) Elevator both section

iii) Elevator legs

iv) Belts for bucket elevator bucket

A receiving hopper or chute to receive material and deliver it to the boot; buckets (cups) fastened to an endless belt move around the boot pulley to pick up material and move, it up the leg to the head. The head includes the head pulley, motor, drive and other parts above the discharge spout the discharge spout delivers elevated material to the desired place or bins.

Operation and performance

As the belt carries the buckets around lower or boot pulley, they scoop up material from the boot of the elevator. The belt carries filled buckets up and over the head pulley, where material is discharged into a desired bin.

Speed at which the belt moves is the chief factor controlling capacity and efficiency of a belt-bucket elevator. Shape of the buckets is designed to permit discharge of material at a certain point as material pass over the head pulley. The belt must be moving at a precise speed to allow the buckets to throw all material into the discharge spout. If the belt is moving too fast, material (grain/seed) may be damaged by being thrown from the buckets against the head shielding of the elevator. Also, few material will fall back down the leg instead of being discharged properly. If belt speed is too slow, all material will not be thrown into the discharge spout, but some will fall back down the leg. Elevator manufacturers normally provide drive pulleys to produce the proper belt speed.

Application

1) Bucket elevators are manufactured in a wide range of heights and capacities to handle conveying operations.

2) Bucket elevators are well suited for small capacity unit like grain-cleaning equipment.

3) Used in large expensive units such as grain, coal, ashes etc. in large industrial plants.

4) Used in seed processing plants.

Merits and demerits

1) Bucket elevators are very efficient to convey the material

2) Power requirement and initial cost is comparatively low.

3) Bucket elevators are more expensive than scrapper conveyors.

4) Difficulty in clean out and limited flexibility.

The bucket elevator capacity may be calculated by the following equation.

Elevator capacity (Q):

Q, m^3/hr = Bucket capacity m^3 x Number of bucket per meter of belt x Belt speed, m/min x 60

$$\textbf{Capacity } t/hr = \frac{\text{Capacity } m^3/hr \times \text{material density } kg/m^3}{1000}$$

The theoretical horsepower requirement for the bucket elevator can be calculate for the following equation –

$$\textbf{hp} = \frac{QHF}{4500}$$

Where Q = Capacity of bucket elevators, kg/min

H = Lift of elevators, meter

F = Factor 1.5 for elevators loaded on the up side and 1.2 for elevator loaded on the bottom side

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Exercise No. 15

VISIT TO SEED PROCESSING PLANT

A Report of Visit of Seed Processing Plant

Proforma :

Sr. No.	Particulars	Information
01	Name of seed Processing Plant	
02	Capacity of Seed Processing Plant	
03	Name of different processing machineries installed	
04	Capacity of each processing machine	
05	Flow diagram of Processing plant	
06	Processing operations taking place	

07	Processing plant layout	
08	Rated and Actual capacity of Plant	
09	Remarks and Suggestions for Improvement	

Any other points :

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Exercise No. 16

VISIT TO POST HARVEST LABORATORIES

Syllabus

Course :	ENGG 364		Credit:	2 (1+1)	Semester-VI

Course title	Protected Cultivation & Secondary Agriculture

Theory

Green house technology: Introduction, Types of Green Houses; Plant response to Green house environment, Planning and design of greenhouses, Design criteria of green house for cooling and heating purposes. Materials of construction for traditional and low cost green houses. Irrigation systems used in greenhouses, Important Engineering properties such as physical, thermal and aero & hydrodynamic properties of cereals, pulses and oilseed, their application in PHT equipment design and operation. Drying and dehydration; moisture measurement, EMC, drying theory, various drying method, commercial grain dryer (deep bed dryer, flat bed dryer, tray dryer, , re-circulatory dryer and solar dryer). Material handling equipment; conveyer and elevators, their principle, working and selection.

Practical

Study of different type of greenhouses based on shape. Study of Greenhouse Covering and Construction Materials. Study of Cooling System used in Green House. Study of Irrigation System used in Green House. Cost Estimation of Poly houses for 560 Sq.m Study of greenhouse equipment's. Visit to Commercial Green House. Visit to various Post Harvest Laboratories. Determination of Moisture content of various grains by oven drying & infrared moisture methods. Study of Grain Dryers. Study of Material Handling Equipments. Determination of engineering properties (shape and size, bulk density and porosity of biomaterials).Determination of Moisture content of various grains by Universal moisture meter. Field visit to seed processing plant.

Teaching Schedule

a) Theory

Lecture	Topic	Weightage (%)
1.	Green house technology - Green house technology: Introduction, History of green house, Advantages of green house, Green house effect.	6
2.	Types of Green houses-Types of Green houses: Green house type based on Shape, Utility, Construction and Covering materials	7
3.	Plant response to green house environment -Plant response to green house environment : Light, Temperature, Relative Humidity, Ventilation and Carbon di-oxide.	6

4.	Planning and Design of green house- Planning and Design of green house: Site selection and orientation, structural design and covering materials.	6
5.	Materials of construction - Materials of construction for traditional and low cost green house: Wood, G.I., aluminum, steel, R.C.C. and Glass	6
6.	Irrigation Systems used in green house - Irrigation Systems used in green house: Rules of watering, Overhead Sprinklers , Drip irrigation system and Foggers (Mist spraying)	6
7.	Design criteria of green house for Cooling and Heating purposes - Design criteria of green house for Cooling and Heating purposes: Cooling - Natural ventilation, forced ventilation Heating- Heating system, solar heating system, Water & Rock storage.	6
8.	Engineering Properties - Engineering Properties of cereals, pulses and oil seed. Their applications in PHT equipment design and operation: Physical properties: Size and Shape (Roundness and Sphericity) Porosity, Coefficient of friction, and angle of repose, Thermal properties: Definition of Specific heat and Thermal conductivity. Aero & hydrodynamic properties: Definition of Terminal velocity	6
9.	Drying and Dehydration - Drying and Dehydration: Definition of drying and dehydration, Utilities/Importance of drying Grain drying Theory- EMC definition, Thin layer drying and deep bed drying	6
10 & 11	Moisture Measurements- Moisture measurements: Moisture content and its measurement, Moisture content representation: Dry basis and wet basisMoisture Content determination Methods:- Direct methods- Air oven method, Vacuum oven method and Infra-red methodIndirect Methods- Electrical resistance method and Di-electric method .	12
12.	Various Drying Methods - Various Drying Methods: Sun drying, Mechanical Drying Mechanical Drying Methods:- Contact drying, Convection drying, Radiation drying	6
13.	Numerical on Moisture content and its representation- Numerical on Moisture content and its representation: Conversion of wet basis moisture contents to dry basis moisture contents Conversion of dry basis moisture contents to wet basis moisture contents, Problems on drying Problems on moisture contents Problem No.1 & No.2.	6
14 & 15	Commercial Grain Dryers - Commercial Grain Dryers: Construction and working principle - Deep bed dryer, Flat bed dryer, Recirculating dryer – (LSU and Baffle dryers) , Tray dryer and Solar dryers	13
16.	Material Handling Equipments- Material Handling Equipment's: Construction and working principle- Conveyor- Belt conveyor and Screw conveyor Elevator- Bucket elevator	8
	Total	**100**

b) Practical

Experiment	Topic
1	Study of Different Types of Green Houses
2	Study of Green House Covering and Constructional Materials
3	Study of Cooling System Used in Green House
4	Study of Instruments and Equipments used in Green House
5	Study of Irrigation Systems Used in Green House
6	Cost Estimation of Poly-house for 560 sqm.
7	Visit to Commercial Green House
8	Determination of Moisture Content of Various Grains by Oven Method
9	Determination of Moisture Content of Various Grains by Universal Moisture Meter
10	Determination of Moisture Content of Various Grains by Infrared Moisture Meter
11	Determination of Physical Properties of Grains
12	Study of LSU and Baffle Dryers
13	Study of Tray and Solar Dryers
14	Study of Material Handling Equipments-Belt Conveyor, Screw Conveyor and Bucket Elevator
15	Visit to Seed Processing Plant
16	Visit to Post Harvest Laboratories

Suggested Readings

1) Green House Technology & Management by K.RadhaManohar (2000) C.Igathinathane B.S. Publications 4-4-309, Sultan Bazar, Hyderabad-500095.
2) Unit Operations of Agricultural Processing by K.M. Sahay and K.K.Singh (2009)Vikas Publishing House Pvt. Ltd. New Delhi-110007
3) Post harvest Technology of Cereals, Pulses and Oilseeds by A. Chakraverty (1997)Oxford & IBH Publishing Co. Pvt. Ltd., 66 Janpath, New Delhi-110001.
4) Green House management by L R Taft (1997) Biotech Books, Delhi
5) Post Harvest Technology and Quality management of Fruits and Vegetables by P. Suresh Kumar, V R Sagar and M Kanwat (2009) Agrotech Publishing Academy, Udaipur
6) A Text Book of Greenhouse and Post Harvest Technology by B.P. Sawant, J.M. Potekar, H.W. Awari(2008) Nikita Publication, Latur.
7) Green House Technology by G. N. Tiwari and R.K. Goyal(1998) Narosa publishing House, 6 community Centre, Panchsheel Park New Delhi- 110017
8) Green House Technology and Application by V M Salokhe and A KSharma(2006) Agrotech Publishing Academy, Udaipur
9) Emerging Trends in PHT and Utilization of Plant Food by N Khetarpaul et al(2003) Agrotech Publishing Academy, Udaipur
10) Green House Operation and Management by Nelson and Paul V (1994) Prentice Hall, USA

Practical Manual		
Course Title	:**Protected Cultivation and Secondary Agriculture**	
Course No.	: **ENGG-364**	Credits : 2 (1+1)

Semester : VI (New)

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4	Study of Instruments and Equipments used in Green House			
5	Study of irrigation system used in Greenhouse			
6	Cost estimation of poly houses for 560 sq.m.			
7	Visit to Commercial Greenhouse			
8	Determination of Moisture Content of Various Grains by Oven Method			
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15	Visit to Seed Processing Plant			
16	Visit to Post Harvest Laboratories			
	Syllabus			

CERTIFICATE

This is to certify that Mr. / Miss _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Reg. No._ _ _ _ _ _ _ _ _ _ _ _ _ _ a student of **VI Semester (New) B.Sc. (Hons) Agriculture** has completed all the exercises successfully of the Course : **Protected Cultivation and Secondary Agriculture, Course No.: ENGG -364** during Academic year 20 - 20 .

Place:

Date:

Course Teacher